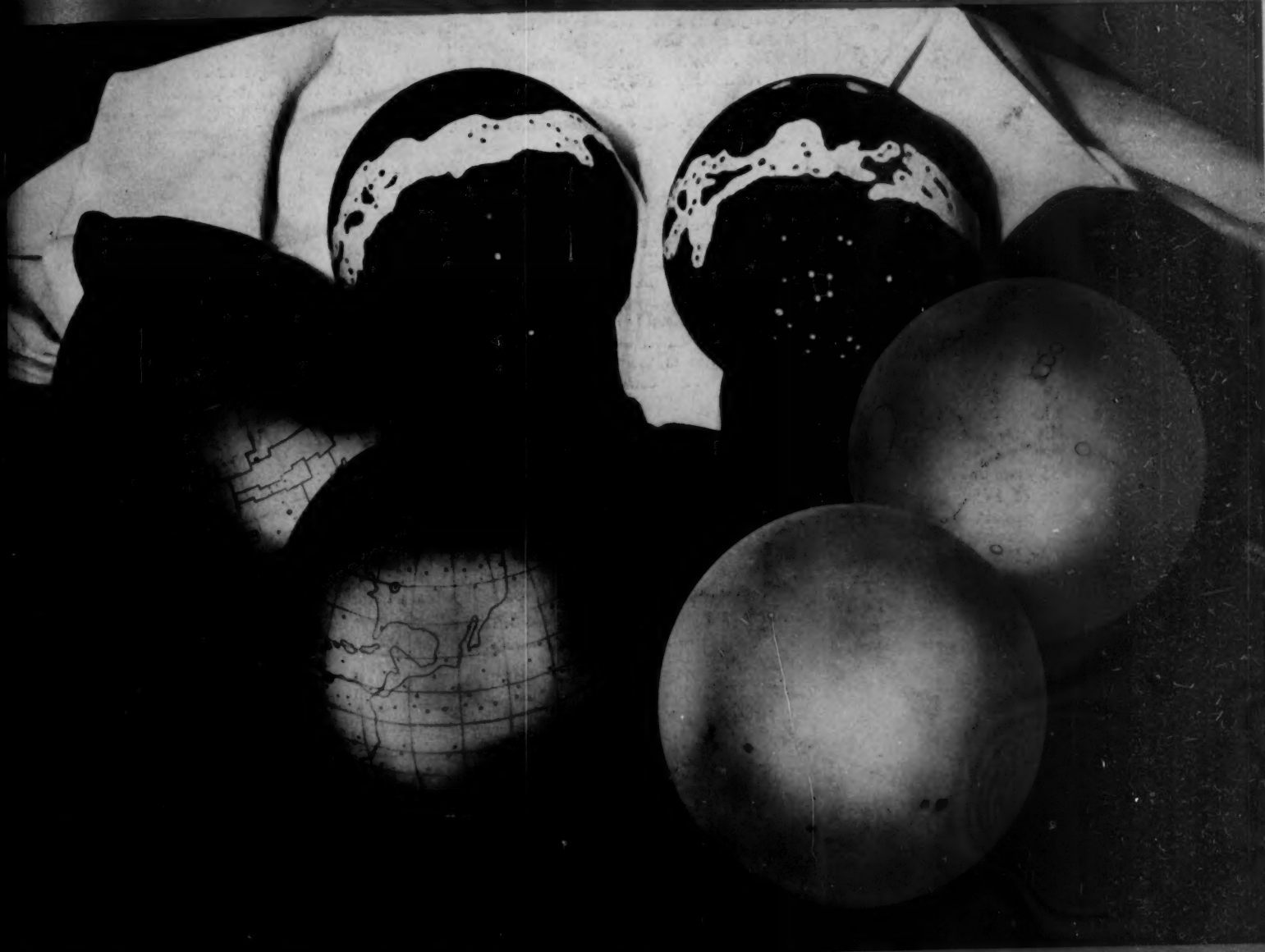


Sky and TELESCOPE



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Vol. II, No. 6

APRIL, 1943

Whole Number 18

20 cents

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In This Issue:

The 1769 Transit of Venus

A Novel Projection Device

An Englishman Renames
the Stars


Interchangeable "slides" for Nebraska star projector.

Another Good Eclipse

Weather Signs in the Sky

Air and Sea and Stars

Adventures of
LONGINES
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two winters in the snow*

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The Editors Note . . .

MOST persons who are familiar with the constellations and stars instinctively rebel against any suggestion that they might be renamed, regardless of whether or not a useful purpose would be served thereby. Apart from one's personal feelings, however, the only really sound objection to such a procedure is the confusion into which the change would plunge astronomical records and studies for some time to come. This one fact makes it doubtful if, during our present civilization at least, any system of naming the stars will replace the one at present in international use.

But these days, when so many persons are becoming acquainted with the sky for the first time, the difficulty of learning strange names and stranger pronunciations becomes a significant factor. The tens of thousands of students in aviation, navigation, and meteorology would save countless hours if star names represented things more familiar in their daily lives and experiences. The coming generation, too,

would spend more time learning the stars if they represented the realities and personalities of modern history, geography, and literature.

There is considerable merit, then, and interest for every amateur and professional astronomer, in the proposition recently made by A. P. Herbert that the sky be refurnished. On pages 12 and 13 are portions of his original story and chart. He closes his detailed and logical explanation of his choice of a name for a certain constellation with the statement:

"About the purely astronomical details and questions—how far, for example, it is practical to reshape some of the old constellations and expect the student to learn the new ones; and how many, and which, stars are worthy to bear names—we must, of course, respectfully consult and be advised by the experts, the astronomers. But upon the general principle that the stars of Heaven deserve at this date to receive new and better names I present my case with confidence to the jury."

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BACK COVER: The Whirlpool nebula in Canes Venatici, M51 (N.G.C. 5194) and its peculiar companion N.G.C. 5195, which appears as an attachment to one of the spiral arms. This was the first nebula to be distinguished as spiral; it has an apparent diameter of about 6' and an apparent magnitude of 11.1. This photograph is a three-hour exposure with the 100-inch telescope at Mt. Wilson, May 15, 1926.

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THE 1769 TRANSIT OF VENUS

and its relation to
early American astronomy*

BY ALBERT E. LOWNES

THE transit of Venus which occurred on June 3, 1769, has a special interest for American astronomers, for with it American astronomy came of age. Rarely has a single event so affected the course of a science.

Some years ago I stumbled upon a number of accounts of the observations of this transit. As I read them, I was struck with the amount of information which they gave on the state of science in colonial America and it occurred to me that it might be interesting to gather together as many of these accounts as I could. When I began, I expected to find a dozen or so related papers. My bibliography now runs to over a hundred titles and new ones turn up at frequent intervals. They are not of equal value, of course, but together they do give fascinating pictures of colonial life. History is a continuous process, but a single event often seems to illuminate a whole era. I think that this transit of Venus was such an event.

We are apt to think of colonial America as a scientific desert, sparsely peopled by men who were so busy seeking God and fighting Indians that they had no time for intellectual pursuits. The fact is very different. Americans, by and large, had as good an education and as high a degree of scientific curiosity as any people in the world. Critics have pointed out that mathematics had no place in the early curriculum at Harvard, but it wasn't taught at Oxford or Cambridge either, in those days! In spite of this, astronomical treatises were written in 17th-century New England. In 1683, for example, Increase Mather published some sermons on comets. To these he added an appendix which proves that Mather was abreast of the scientific attainments of his day. He quotes Kepler and Hevelius and regrets that he is unable to refer to one book by Hevelius because no copy had come to America yet. Nor was it a one-way street. New Englanders could quote Newton, to be sure, but Newton could quote New Englanders, too: a substantial part of the proof of one proposition in Newton's *Principia* rests on the observations of Thomas Brattle, of Boston.

By the eve of the Revolution, a

A portrait of Benjamin West, leader of the observers of the transit at Providence, R.I. Reproduced from the original in the Brown University Archives.



century later, the disparity between English and American culture had all but vanished. By almost any criterion—education, architecture, sanitation, science—America (at least in its more populous regions) lived well and had a stimulating intellectual life.

Transits of Venus are among the rarest of recurrent and predictable celestial phenomena. A transit occurs when the planet passes between the earth and the sun—it is, in effect, a minor eclipse. In all history, only five have been observed. The latest one occurred in December, 1882, and the next one will not come until June, 2004, so that very few of the present readers of *Sky and Telescope* are likely to see one. These transits occur in pairs, always in June or December, the two in a pair being eight years apart, with intervals of 105½ and 121½ years.

Kepler predicted a transit in 1631, but he was a few hours off in his calculation and the sun was below the horizon in western Europe, so that it could not be seen. The first transit that was actually seen was predicted by a young and unknown English amateur, Jeremiah Horrocks, a curate at Hoole, near Preston, in Lancashire. He noticed certain errors in the astronomical tables of Kepler and Lansberg and through his efforts to correct them from his own observations, he determined that a transit of Venus would occur on the afternoon of Sunday, November 24 (O.S.), 1639. He communicated his discovery to his friend, William Crabtree, a Manchester cloth

merchant, and urged him to watch for the event. Poor Horrocks had to conduct vespers at the crucial moment, but as soon as evensong was over, he hurried to his little half-crown telescope and enjoyed the exciting experience of watching the transit for half an hour before sunset intervened. Horrocks died the following year. He was but 23 years old. Some 30 years later, John Wallis published Horrocks' works, but he omitted the account of the transit. He did send it to Hevelius, who published it at Danzig. Still no one attached much importance to this minor work of an obscure English curate.

Toward the end of the 17th century, Edmond Halley realized that a transit of Venus might provide an unusual opportunity to determine the sun's parallax. The transit of 1639 was the second of a pair. Halley calculated that the next one would occur in 1761 and he urged his successors to prepare for it. Details of this and of other methods of determining the sun's distance are told in "Facts About the Sun," *Sky and Telescope*, July, 1942.

In his famous article, Halley stated that a transit of Venus should allow the parallax to be determined with an error of less than one fifth of one per cent. Naturally, as 1761 drew near, the astronomers of the world were agog. The phenomenon was central over the Eastern Hemisphere and expeditions were sent to many far-off places. Chappe d'Auteroche, for example, went to Tobolsk in Siberia at the invitation and

* This article is the substance of a talk given to the Providence Art Club on January 22, 1943.

under the protection of Catherine the Great; Nevil Maskelyne went to the Cape of Good Hope; Le Gentil went to India. The weather was bad almost everywhere, particularly in the European centers where the best instruments were assembled. Le Gentil, driven out of India by the outbreak of war between France and England, saw the transit perfectly from his ship, but the rocking observatory did not permit him to make a single useful observation. He decided to remain in the Orient for eight years so as not to miss the transit of 1769. This time a cloud spoiled his observations. When he arrived home at last, he found that he had been declared legally dead. From the wreckage of eight years, Le Gentil salvaged one crumb—he was able to write a scholarly treatise on the astronomy of the Brahmins.

The transit of 1761 was visible in America only in Newfoundland. The Colony of Massachusetts Bay financed an expedition led by John Winthrop, of Harvard, to St. John's, where Winthrop and Samuel Williams caught the end of the transit just at sunrise.

With such unfortunate conditions, the anticipated results of the transit of 1761 turned out to be inconclusive. That of 1769 was awaited with increasing interest and excitement.

This time the phenomenon was central over the Western Hemisphere. As before, many expeditions were sent out from Europe. England and France agreed to a truce so that the astronomers would not be hampered. The British sent out a shipload of men and instruments under the command of Capt. James Cook to the newly discovered island of Tahiti. Cook landed his party and then took advantage of his free time to discover and explore New Zealand and the east coast of Australia, so a new continent on this earth was an unexpected by-product of the transit.

The main French expedition under Chappe d'Auteroche chose the southern tip of Lower California. Chappe arrived there eight days before the transit, but an epidemic was raging and his companions urged him to move on to a more healthful spot. Chappe maintained that the observation of the transit was more important than personal safety. The observations were carried out successfully, but two days later many of the men were taken sick and, finally, Chappe himself. In spite of this, he continued to work on his calculations. He died on August 1st, but his work was nearly done and his precious manuscript was sent back to France and published in 1772. Dead, besides Chappe, were his clockmaker, the interpreter, one of the two Spanish officers, four officers sent from Mexico, 12 soldiers, and about 50 Indians. Other French expeditions were

at San Domingo and Martinique in the West Indies.

No less than 16 observatories were set up in the British colonies of North America where careful observations were made in a positive attempt to obtain scientific data. Probably there were others, but I have fairly complete stories of each of these 16. Here is evidence of widespread curiosity and a concerted effort at scientific co-operation. It goes far to dispel the notion that Americans were scientific illiterates.

Americans had plenty of notice of the impending transit. Maskelyne, Astronomer Royal of England, prepared a 44-page pamphlet of instructions for them. Many institutions had sets of *Philosophical Transactions* with Halley's classic paper and reports of 1761. In March, Prof. Winthrop read two lectures at Cambridge and these were rushed into print. The newly reorganized American Philosophical Society in Philadelphia backed three observatories at nearby points. It is illuminating to read in the minutes of the society that before a decision was reached, an inquiry was made "to know whether the Indians would allow proper Persons to pass through their Country in order to make the Transit of Venus observations." The society also acted as a clearinghouse for information. Newspaper editors and almanac makers did their share toward spreading the word. Curiously enough, the almanac published in Providence by "Abraham Weatherwise" stated that the transit would be invisible in Britain or America.

The 16 observatories that I have studied were at Prince of Wales Fort on the northwest coast of Hudson Bay; at Ile aux Coudres and Quebec in Canada; at Boston, Cambridge, Newbury, and Edgartown, Mass.; Newport and Providence, R. I.; Baskenridge, N. J.; Norriton and Philadelphia, Pa.; Wilmington and Lewes, Del.; Talbot County, Md.; and Rosewell, near Williamsburg, Va. More or less detailed accounts of each of them are available—the names and positions of the observers; the apparatus at hand; an account of the transit; and sometimes a full report of the calculations and the determination of a solar parallax.

Each observatory had to have an accurate timepiece and a telescope as minimum equipment, but most of them went far beyond this. Many of the stations had equal altitude and transit instruments. Dollond micrometers were frequent. Some observers had quadrants or sextants. Providence seems to have had the only helioscope. Hudson Bay had Fahrenheit thermometers and a barometer! Much of the apparatus was homemade and it was often extremely ingenious. The names of 16 different instrument makers occur in the accounts. As might be expected, a majority of

these are English, but Americans were well represented.

Reflectors outnumber refractors among the larger telescopes, but if we include smaller instruments, refractors are in the majority. The largest reflector was one purchased in England by Benjamin Franklin for the Hon. Thomas Penn. It was lent by Penn to the Philadelphia observatory and subsequently given to the college in that city. It was made by Nairne and had a focus of 4½ feet with a 7-inch aperture. The two largest refractors were at David Rittenhouse's observatory at Norriton. The larger is described as "A Refractor of 42f. its magnifying power about 140. The glasses were sent from London . . . and belonged to Harvard College, New-England; but as they did not arrive time enough to be sent to that place before the Transit, they were fitted up here by Mr. Rittenhouse; and used by Mr. LUKENS." The instruments used by John Winthrop in his observation of the transit of 1761 had been burned in the fire at Harvard Hall in 1764, and it had been necessary for Harvard to order new equipment. I wish Winthrop's opinion of this casual appropriation of his new telescope had been preserved. I imagine that he said a few pointed things to the men in the City of Brotherly Love! The second big refractor at Norriton was made by Rittenhouse himself.

One of the telescopes used in Philadelphia was a 24-foot refractor belonging to Miss Norris. One would like to know more about this lady, for even today female owners of 24-foot telescopes are unusual.

The two Rhode Island observatories were average—neither the largest nor the smallest, nor the best nor the worst equipped. Their story may give you an idea of how our American scientists set out to solve one of the great problems of astronomy.

The prime mover in Providence was Benjamin West—or was he? Accounts differ. Benjamin West, who was born on a farm in Rehoboth, Mass., in 1730, was a most interesting character. He had almost no formal schooling, but he read books avidly and he was a natural mathematical prodigy. At various times he supported himself by teaching school, running a store, manufacturing clothing for the American army, and as postmaster at Providence. For some years he was a professor at Brown University (then Rhode Island College) and for 30 years he published an almanac, based on his own observations. In spite of his varied efforts, he was rarely able to solve his own basic financial problems.

Then there was Joseph Brown, second of the four brothers—"John and Jose, Nick and Mose"—whose commercial exploits and philanthropies fill a colorful chapter in Rhode Island history. Brown read Winthrop's account of the transit

of 1761 and became convinced that an observation of the coming transit would be of value to navigators. He asked West, who was the town's leading astronomer, for a list of necessary equipment, which he ordered through his London agents. "Mr. Brown's expence, in this laudable undertaking, was little less than One Hundred Pounds sterling, besides near a month's time of himself and servants, in making the necessary previous experiments and preparations." So says West in his published account. According to the Reverend David Sherman Rowland, pastor of the First Congregational Church in Providence, the laudatory passage quoted was forced upon West by Brown, "contrary to what was really just and right." It does appear as a footnote.

But Joseph Brown was a man of parts. He is the least known of the four brothers, possibly because he died at a comparatively early age. He was a first-rate architect and builder. The five structures which he built still stand, the chief architectural treasures of Providence. He built and operated a steam engine—perhaps the first in America—at the Cranston bog-iron orebeds. He retired from business to accept a professorship, which he filled with distinction, at Rhode Island College. It isn't fair to dismiss him, as Rowland did, as a publicity-seeking Maecenas. The Providence account was the first to be published, except for brief newspaper stories, and the only one printed as a separate document. If Brown saw it through the press, he deserves some credit.

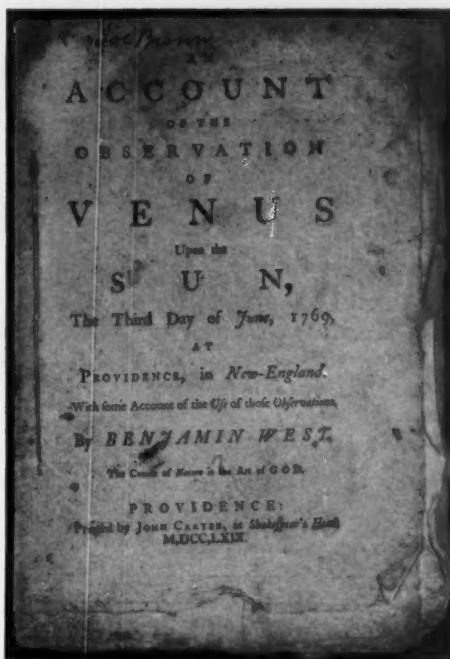
The transit was observed by West, Stephen Hopkins, Moses Brown, Dr. Jabez Bowen, Joseph Nash, and Capt. John Burrough at an observatory erected on a hill near the present Transit Street. David Howell, the first professor on the college faculty, was also in the party, according to his own letter of June 5, 1769. No doubt Joseph Brown was on hand, too, although West does not mention him in that connection.

"Our apparatus," says West, "consisted of a three feet reflecting telescope, with horizontal and vertical wires for taking differences of altitudes and azimuths, adjusted with spirit-levels at right angles, and a divided arch for taking altitudes; a curious helioscope, together with a micrometer of a new and elegant construction, with rack motions and fitted to the telescope . . . Besides the before mentioned instruments, we had a sextant belonging to the government, made in Newport by Mr. BENJAMIN KING, under the direction of JOSEPH HARRISON, Esq. now Collector of his Majesty's Customs for the port of Boston; its limb was divided to five miles, and by a vernier index to five seconds.—We had two very good clocks, one of which was made in Providence, by Mr. EDWARD SPALDING."

West then goes on to explain that the

only instrument new to the observers was the "catadioptric micrometer, which, I have lately learned, was of DOLLOND's construction; not having any author by us, from which we could get the use of that curious instrument, we were obliged to have recourse to experiments."

The Providence astronomers also built a device to trace an accurate meridian line so that they could regulate their clocks with great exactness. Various experiments with stiles and sextants did not give a sufficiently close figure for



The author's copy of West's account—a first edition which possibly belonged to Joseph Brown, whose name appears at the top of the title page.

latitude, so Mr. Brown worked out a new method using the micrometer as a lens. The longitude was determined by observing the emersions of Jupiter's satellites and comparing the results with corresponding observations made by John Winthrop at Harvard. So much for Providence.

The Newport observatory was directed by Ezra Stiles, minister of the Second Congregational Church in that town and later president of Yale. While Stiles was still in college, he carried out electrical experiments which brought him the lifelong friendship of Benjamin Franklin. His diary, preserved at Yale, gives a lively picture of Newport life. Among his papers is a separate quarto volume devoted to this transit of Venus.

By May 4, 1769, Stiles was looking forward to the event, for he tells that he read that day in Smith's *Optics*, vol. 2, and began on Winthrop's two lectures. Other entries follow: "May 23. Employed in preparing for the Transit of Venus. May 25. Employed in taking equal altitudes, etc. May 26. Getting an astron. Sextant made. [No doubt this sextant also was made by Benjamin

King and modeled after the one used in Providence.] May 27. Last night let down two Threads pendant from my Garret Windows, & affixed weights at the bottom, and immersed them in two vessels of water; then ranged them to Alioth and the pole star. This noon regulated the two clocks to the meridian."

Then on June 1st: "Finished Sextant for observing the Transit of Venus."

"June 3. Fine serene day. Assiduously employed in observing the Transit of Venus . . ."

"THE ARRANGEMENT OF OBSERVATORS: Mr. Benjamin King at the Tube of the Sextant. Mr. William Vernon and E.S. at the perpendicular Hair or Plumb. Mr. Henry Marchant at the Reflecting Telescope. Mr. Henry Thurston with a good Prospective at Corner House."

"In the House at the Clocks: Mr. Townsend's Clock: Mr. Punderson Austin, Mr. Christopher Townsend; E. Stiles's Clock: Mr. William Ellery, Capt. Caleb Gardner . . ."

"I saw the moments of external & internal Contacts, the first at 11^h. 31'. 27". P.M. app. Time; the latter at 11^h. 46'. 46". P.M. Difference, fifteen minutes eighteen seconds. We took 27 Altitudes of the sun on the day of the Transit. There were three observers at the same Time looking at the Sun. I was the first that espied Venus's Entrance, the other two soon saw it tho' not till several seconds after I gave the word. The moment of Immersion, or first internal contact, was seen by two of us, Mr. William Vernon & myself, both gave the word at the same instant. We had two observers at each of the clocks. At Sunset Venus had passed the middle of the Transit and sat in the Sun's Disk."

When the returns of observations and calculations on the sun's parallax were in, Maskelyne, in England, was moved to announce that the American observations were among the best. Well he might.

David Rittenhouse developed a new and improved method of calculation which gave him a parallax of 8.805 seconds of arc, which is in amazing agreement with the figure of 8.803, the accepted value until a very few months ago when the present Astronomer Royal, H. Spencer Jones, announced a refined value of 8.790 based on observations of Eros in 1931.

No doubt astronomers of 2004 will watch for the transit of Venus with a great deal of interest, and they may learn things from it which we do not dream of, but I doubt if they will be any more excited than were our ancestors in 1769. At any rate, the establishment of 16 observatories, well equipped in accordance with the standards of the time, and the ability to staff these observatories with trained astronomers suggest to me that America was far from a scientific desert.

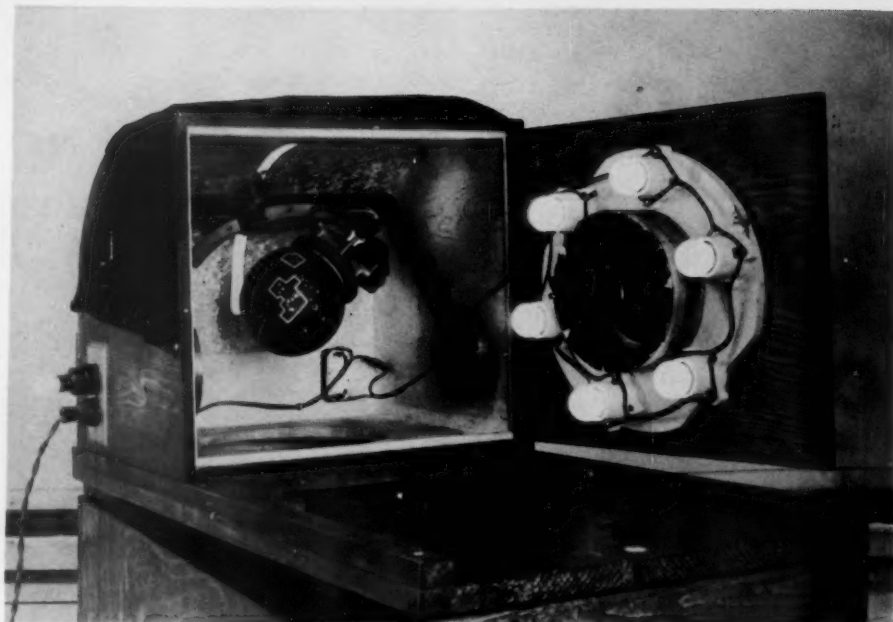
A NEW type of projection apparatus has been in successful operation in our astronomy courses at the University of Nebraska for the past two years. Its primary purpose is to facilitate the learning of the constellations and the study of the daily motion of the sky as seen from different latitudes. An account of the device may be of interest to all concerned with the practical problem of giving swift instruction to men in the Services.

The cost of construction was less than 50 dollars. No dome or special building is required. Only an ordinary screen or flat wall is needed, and the instrument can be used in any room which can be darkened. It is easily transported and has been shown in divers places.

The device is comparable in size and cost and also in use with an ordinary lantern-slide projector. Used in a darkened room, it shows by projection a representation of the night sky. Only such portion of the sky is shown at one time as falls on an ordinary lantern screen, but this is just so much as an observer would normally see out of doors without turning his head. The rotation of the heavens is realistically produced, so the daily risings and settings of the heavenly bodies are shown. In addition, all parts of the sky may be observed in turn, and there is no changing of slides from constellation to constellation. And finally, while the audience remains facing the screen, the supposed direction of vision may be changed to any other part of the sky.

The stars and constellations appear spaced according to the proportions of their angular separations. Differences of magnitude are indicated by the sizes of the illuminated star images and the stars are shown in colors to indicate their spectral types. For each part of the sky there may be superimposed at will on the screen-representation additional material, such as the circles of declination and of right ascension, the boundaries of the constellations, the mythological figures or the names of constellations, star names, or the outlines of the Milky Way.

The apparatus differs from ordinary lantern-slide representation in the following respects. The constellations can be shown "the right way up" for any time or place, that is to say, they can be made to appear in proper relation to the vertical as they would be seen from any latitude at any hour of the night at the proper season of the year. Each constellation is shown in its true relation to other constellations. The scale of the projection may be varied at will so as to show a single constellation large, and alone, or diminished in size and surrounded by a group of several adjacent constellations. By reducing the magnification sufficiently, it is possible to show at once all of the sky which is above the



An interior view of the projector shows one of the star "slides" in place.

A NOVEL PROJECTION DEVICE

BY OLIVER C. COLLINS, *University of Nebraska*

horizon at one time. This last representation is in effect the familiar planisphere projection (made for holding overhead) and, like it, can be set for any hour and season and also for various latitudes. It differs, however, from the planisphere representation in that azimuthal directions from the observer's zenith are uniformly spaced and are not determined by curved lines.

The portion of the device which corresponds to the ordinary lantern slide can be changed as desired, but it is possible to show all the sky from a celestial pole to 50 degrees beyond the celestial equator without such change. This means that the entire sky visible in our latitude, or in any latitude farther from the equator, can be shown without changing slides, and that two slides and only two are needed for showing the entire sky from pole to pole. Accordingly, pairs of slides may be used which show the entire sky with any selected space direction as the axis, and we may base our reproduction on the ecliptic system or the galactic (Milky Way) system if we desire to emphasize either of these.

The device is not limited to the foregoing applications, but may be used for projections of lunar, solar, or planetary surfaces (see front cover), and, in fact, for the screen-presentation of any spherical surface and for the illustration of problems in spherical trigonometry and navigation. In all applications these facts

are of value—that any portion of the surface can be brought to the center of the screen for special notice, and magnified if desired, and that adjacent portions are found in their proper relative positions. The librations of the moon may be simulated and the apparent paths of sunspots at different seasons exemplified. The angles of a spherical triangle may be seen without distortion by perspective as each in turn is brought to the center of the screen and viewed squarely.

The principles employed are those of opaque-object projection and transparency projection so combined that each type may be used alone or both may be used together. The object projected is a portion of a sphere. The optical projection of a spherical object on a flat screen calls for considerable depth of focus in the lens system and is accomplished satisfactorily for a spherical cap of diameter up to 80 degrees or a little more. For example, with Polaris near the center of the screen, the stars of the Big Dipper and of Cassiopeia can be shown at the same time throughout their circuit of the celestial pole. The attempt to show a larger portion of the surface in good focus at one time would appear to call for specially designed lenses, and this problem is still receiving attention. The lenses at present in use are two simple convergent lenses of large diameter (about four inches). One of short focal length is placed near the sphere to be projected, and forms a magnified virtual

image which serves as the object for a lens of greater focal length which projects a real image on a wall screen six feet square and about 15 feet distant. Variation of the distances of the lenses from the sphere and from each other permits a choice of scale in the representation on the screen. Light is supplied from within the sphere for the illumination of the stars, and by a ring of small lamps circling the near lens for use when the markings on the outer surface of the sphere are to be projected.

The sphere, which corresponds to the slide in an ordinary projection lantern, may be changed at will. A spherical cap of its surface some 60 degrees in diameter is absent so as to admit a 30-watt spherical electric lamp, the outer surface of which is treated to provide a good diffusing surface. The lamp is mounted on an axis about which the sphere can be rotated and a small synchronous motor provides "diurnal motion" at the rate of one rotation in about 40 seconds. For the diurnal motion as seen from the Southern Hemisphere, an additional gear is needed to reverse the direction of rotation. The axis of the lamp and sphere is adjustable at any angle from 0 to 90 degrees to correspond to the supposed latitude of the observer. When this adjustment is completed, the representation on the screen shows some portion of the sky which is above the horizon at a place in that latitude. Other portions of the sky above the horizon at the same time at that place are brought into view by manual adjustments in the machine which correspond to supposed changes in the azimuth and altitude of the observer's line of vision. Parts of the sky below the horizon rise into view when the diurnal motion is applied.

The stars which pass through the zenith give an indication of the latitude to which the machine is set. The mo-

tions of the stars, or of the co-ordinate circles when shown, reveal in what direction the observer is supposed to be looking. The stars on the meridian indicate the sidereal time for any particular position of the sky. Or the sidereal time may be estimated by turning to the circumpolar stars. From this, of course, is easily figured the mean time at the assumed place of observation for the supposed season of the year.

The fact that one globe shows the sky extending from the south celestial pole to as far as 50 degrees north of the celestial equator is of particular value in that those who have not as yet seen the southern constellations can be prepared to recognize them by learning their positions relative to constellations already familiar.

The interchangeable spherical "slides" are globes about five inches in diameter and are of glass frosted by grinding on the outer side. The entire outer surface is rendered opaque by black paint except for apertures of appropriate sizes in the proper positions for the stars. Transparent colored inks applied to these frosted apertures give the proper color for each star to correspond with its spectral type.

On the blackened outer surface of the sphere, lines and figures in white are drawn and these show by projection when the secondary illumination is turned on. Since inscriptions in white on this blank surface are easily made, and as easily painted out again, this means is employed also for showing temporary features such as the positions of the planets or the paths of comets.

When representation of lunar or other surfaces is desired, the blackening of the outer surface of the globe is omitted and the necessary features depicted directly on the ground glass surface and illuminated from within. Alternatively, the en-

tire surface may be blackened and serve as a blackboard for figures to be projected by the secondary illumination alone.

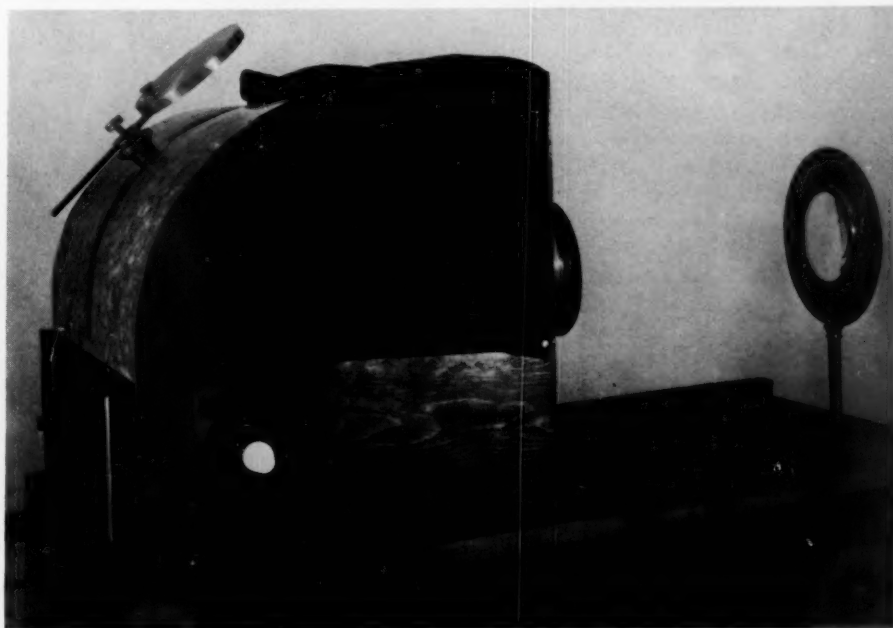
The mechanism by which the sphere is turned is carefully adjusted so that the sphere's center does not change position. Thus one part of the spherical surface replaces another before the lens, and good focus is maintained.

The entire apparatus is mounted in a light-tight box with an aperture for adjustable support of the first lens. The second lens stands in front of this aperture and the system is focused by a differential movement of the first lens and the box.

All manipulation of the position of the sphere is made from outside the box, which need be opened only when a change of the spherical slide is required. The adjustment for the supposed altitude of the observer's line of sight is made by a partial rotation, up to 90 degrees, about a horizontal axis perpendicular to the axis of the lens system. To effect this, the globe is carried on a rectangular yoke and the latitude quadrant to which the axis of the globe is attached is adjustably connected to a swivel at the mid-point of the yoke. This swivel extends through a slot in the box, the back of which has a cylindrical shape to conform to the path of the middle, or horizontal, member of the yoke. A photographic dark cloth hangs over the back of the box to cover this slot, and the operator controls the sphere by placing one hand under the cloth and moving the swivel. This swivel may be rotated in either direction to correspond with the observer's supposed motion in azimuth, and may be raised or lowered along the slot to produce a change in the supposed altitude of the line of sight. Adequate counterpoises make this hand control sufficiently delicate; friction grip in the swivel holds the position steady when the hand is removed.

An off-on switch controls the diurnal-motion motor. Another switch turns on or off the secondary illumination of the outer surface of the sphere. There is but one electrical inlet necessary. The total cost for all parts and for a mechanic's work was less than 50 dollars, not including any cost for work in the preparation of the globes. The actual construction of the mechanical parts took but a few hours of the time of one mechanic, and the star globes were prepared in an equally short time. The glass spheres used were bought at a local store and at first contained artificial flowers.

On many cloudy nights during the past winter it has seemed well worth while to keep the star and constellation names in mind by a few minutes' exercise with this device. Its applications to the teaching of star identification and other navigational problems are obvious.



An exterior view of the projector, showing the manual control device.

BEGINNER'S PAGE

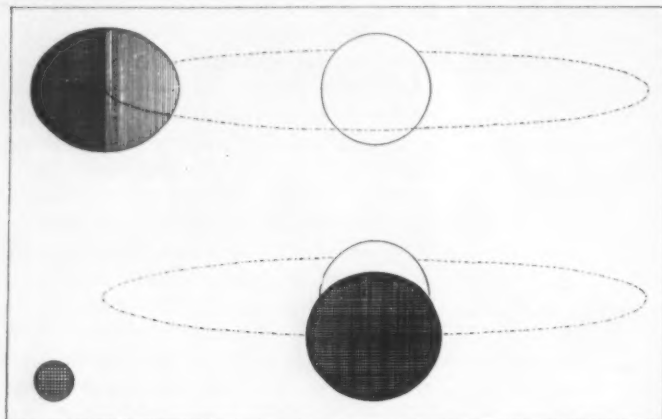
VARIABLE STARS—II

AN indication that the number of variable stars was not expected to be large is the fact that they were designated by the letters from R to Z in the order of their discovery in any constellation. As the number increased, these letters were doubled, then followed by AA, AB to AZ, then BB to BZ, and so on, omitting the letter J. QZ was thus the 334th variable in any constellation. The next is marked V335, and numbers then continue the sequence. The Variable Star Commission assigns the names after a proper verification of a star's

have proved to be of great value.

Over 30 per cent of these stellar eclipses are total, but there are more that are annular or partial. There are all degrees of relative brightness between the components of a system. Beautiful contrasts in color are seen, as in Zeta Aurigae, where a blue star is associated with a red supergiant 70 times its diameter.

The observations of a variable are arranged in a graph with the magnitudes plotted vertically and the corresponding times horizontally. Such a *light curve* of



Stars cease to be simple spheres when they are parts of close binaries, as illustrated by this model of Algol. The practically spherical brighter and more massive component distorts its mate by tidal action. The lower diagram shows the position of the stars at minimum brightness. On the left is shown the size of the sun on the same scale.

variability and the determination of its period and type. Until the final designations are adopted, provisional numbers are used, such as 2.1943, which indicates the announcement of the discovery of the second variable in 1943, or a serial number is given in a list of the discoveries made at a large observatory such as Yerkes or Harvard.

The first observers estimated the changes of magnitude of a variable in comparison with a nearby star that was believed not to change. A good observer was able to note a change of 0.1 magnitude under favorable circumstances. A standard sequence of circumpolar stars was established by photometry at Harvard Observatory, and later, similar comparison stars were listed in regions covering nearly the whole sky. An observer can now usually observe directly the differences between a variable and comparison stars of slightly different magnitudes conveniently located in the same region. As photographic plates easily show stars one million times fainter (at the 16th magnitude) than a 1st-magnitude star, and photometric estimates are now made to 0.01 magnitude, the importance of an accurate standard is evident.

When Goodricke showed in the early part of the 18th century that the variations of the light of Algol could be explained by the rotation of two bodies about a common center of gravity, thereby producing a stellar eclipse, he started a series of investigations that

an eclipsing system of stars can be used to determine the relative sizes and shapes of the components and of their orbits in terms of the diameter of one of the stars. As some of these systems are near enough to allow their distances to be measured in terms of the astronomical unit, the dimensions of the system can then be calculated.

The range of size is staggering. At the lower limit are the invisible companions whose presence is detected by their effect on the orbit of their larger companions, such, for example, as the third (and possibly a fourth) companion of Algol.

At the upper limit is S Doradus in the Large Magellanic Cloud. According to Dr. Sergei Gaposchkin, this system consists of twin stars about 1,800 million miles in diameter (the diameter of Saturn's orbit) which revolve about a common center of gravity in about 40

BY PERCY W. WITHERELL

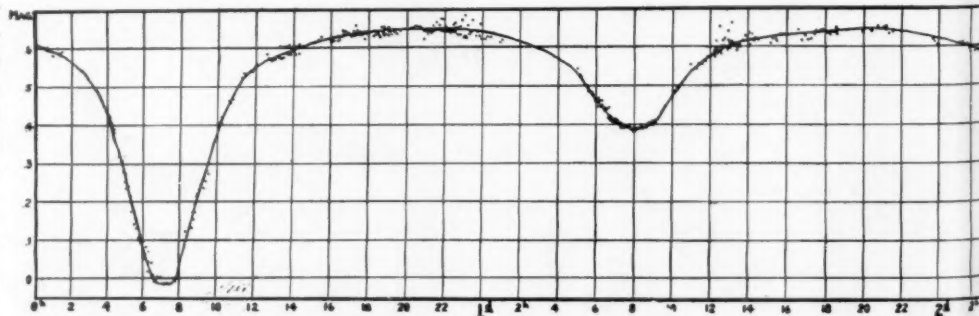
years. The system's actual brightness is about 600,000 times that of the sun, but as it is 95,000 light-years from us, it is only recently that the above data have been computed.

Before this determination, the longest known period for an eclipsing double star was that of Epsilon Aurigae—27.08 years—in this case the dark component has a diameter 2,400 times that of the sun! In contrast, consider UX Ursae Majoris, with a period of less than five hours and a diameter of about 0.3 that of the sun.

Sometimes the components are ellipsoidal and almost in contact, and in Beta Lyrae it is thought that they have a common envelope (*Sky and Telescope*, March, 1942). RY Scuti is a rapidly rotating pair that is enclosed in a shell of gas.

It has often been stated that if any other star had planets revolving around it as does the sun in our solar system, we could never verify it. Dr. K. Aa. Strand has shown that the orbit of 61 Cygni, long known as a visual binary with a period of 720 years and a separation of its components of 10 billion miles, has small, regular deviations. This suggests the presence of a third body. Consider an object about 16 times the mass of Jupiter and revolving around one of the components in five years, in a very eccentric orbit which allowed an approach within 65 million miles of its master. Such an arrangement would account for these perturbations. As this object is only 1/60 the mass of the sun (the "lightest" known stars are about 1/10) and at its nearest to its primary is only two thirds the distance of the earth from the sun, is it not a fair inference that this is a "planet"?

The spectroscope has assisted in revealing thousands of eclipsing systems. None of these can be separated into components by telescopes, but their spectra have shown much about their composition and other characteristics. Our long-distance view of the "experiments" in the laboratory of the universe reveals to us many facts that we can only partially duplicate in our terrestrial laboratories.



The light curve of u Herculis, which has a period of a little over two days, is typical of close eclipsing systems. This is a photoelectric curve; note the small scatter of the individual observations.

NEWS NOTES

By DORRIT HOFFLEIT

CELESTIAL TARGET PRACTICE?

How to get to the moon or Mars? That problem will never rest. Wartime, especially when ordnance departments are seeking farther-range firing equipment, recalls this much farther-range problem. Dr. Robert S. Richardson, in *Leaflet No. 168* of the Astronomical Society of the Pacific, aptly reviews the interplanetary transportation situation. How easy it would be to get to Mars if our earth had neither gravitational force nor an atmosphere! By carefully planning departure times, and co-operating with nature so as to reduce effort to a minimum, we would have to send a projectile off with an initial speed of only 0.78 miles per second. (In the first World War, the Germans shelled Paris with 265-pound shells having muzzle velocities of about a mile a second.) This low initial velocity is possible because we would be firing at the smallest possible angle against the powerful solar gravitation. The projectile would travel the longest path between the two planets, taking 237 days to Mars' aphelion.

Now, however, to outdo the restraining influence of our earth's own gravitational field, the projectile would have to move at least 6.95 miles a second—pretty formidable, but not discouraging in view of general scientific and technological progress. But in addition we must take the atmosphere into account. We know that, to our own advantage, the atmosphere acts like a stone wall to high-speed meteors, succeeding in destroying practically all of them before they can pound upon the surface of the earth. The resisting force increases as the square of the velocity. Getting through the atmosphere is thus the chief obstacle to interplanetary communication. Nevertheless, Dr. Richardson says, "He must be bold indeed who can say to posterity that man can 'never' communicate with other worlds than ours."

MOON-STRUCK IRIS

Some people can't sleep in perfect darkness, but neither can they sleep when the lights are bright. A South African member of the iris family, *Morea iridoides*, growing in Southern California, seems to have a lunar complex about its flowering habits. A psychologist, Prof. Knight Dunlap, of the University of California at Los Angeles, has been observing this plant and finds that the *Morea*s normally bloom within two periods in each lunar month. One period begins about the date of first quarter, the other starts with last quarter; during new or full moon the plants stand bare-stemmed or nearly so. Prof. Dunlap finds apparent exceptions to this behavior associated

with spells of high summer fog which materially reduce the illumination received by the plants.

It will be of interest to see if Prof. Dunlap's discovery is corroborated by further observations, especially of plants growing at other places. We do not have at hand the exact data to test for statistical significance or "spurious period" effects (such, for example, as are sometimes encountered in the determination of variable star periods when the observations are limited to a comparatively short time interval). Astronomers are accustomed to thinking about the moon's influence on the earth in terms of gravitation, tides, and psychological effects on individuals. What the observations of the *Morea* signify, Prof. Dunlap does not feel ready to state, but he comments that they present evidence for the familiar statement, "Ancient superstitions often have foundation in fact."

ASTRONOMICALLY NAMED VESSELS

Carroll Perry, Jr., of the U. S. Maritime Commission, gives us the information that two ships besides the *S. S. George E. Hale* (see *Sky and Telescope* last month) have been assigned names of astronomers: the *S. S. Simon Newcomb* and the *S. S. Maria Mitchell*, both of which have been built by the California Shipbuilding Corporation at Wilmington, Cal.

Simon Newcomb (1835-1909) was commissioned professor of mathematics in the U. S. Navy by President Lincoln, was observer at the U. S. Naval Observatory, and superintendent of the American Nautical Almanac Office. He will always be remembered for his books popularizing astronomy; probably no other American has ever done more than Newcomb did for promoting the astronomical knowledge of the layman.

Maria Mitchell, whose fame is perpetuated in the Maria Mitchell Society and the Maria Mitchell Observatory at Nantucket, was the modest efficient professor of astronomy at Vassar College who discovered a comet and was the first woman ever elected to membership in the American Academy of Arts and Sciences.

THORIUM IN THE SUN

A search for the rare radioactive element, thorium, in the sun—began in 1938 but delayed by insufficient experimental laboratory work—has now proved fruitful. According to a Science Service report, Dr. Charlotte E. Moore, of Princeton Observatory, and Dr. Arthur S. King, of the spectroscopic laboratory at Mt. Wilson, find that the strongest laboratory lines of the ionized element

coincide with hitherto unidentified lines in the solar spectrum.

Only ionized atoms of thorium have as yet been recognized in the sun. Spectral lines of the neutral atoms should appear stronger in sunspots than in the surrounding hotter surface of the sun. The only lines in the solar spectrum whose wave lengths agreed closely with laboratory lines of neutral thorium were not found strengthened in the sunspots. The investigators therefore rejected these coincidences as accidental, and claim success only for ionized thorium.

MORE ELEMENTS IDENTIFIED IN METEORITES

In a recent article in the *Astrophysical Journal*, W. A. Johnson and Daniel Norman, of the New England Spectrochemical Laboratories, report on a spectrographic study of 18 meteorite samples. Their tests enabled them to make estimates of the relative volatility as well as the relative abundances of the various elements found. They looked specifically for 69 elements and found 40, of which 12 were not found by Dr. A. S. King's classical spectroscopic study of meteorites in 1936. These newly identified elements are: arsenic, cadmium, indium, iridium, mercury, palladium, platinum, tellurium, thulium, and zirconium.

No obvious grouping of the 18 meteorites could be made on the basis of their atomic constituents. In the future, the authors hope to carry out an investigation on the variation of the distribution of the minor elements throughout a single meteorite. As yet practically nothing is known on the distribution of the more volatile elements as one goes from the center of a meteorite outward.

EDUCATION STILL PROGRESSES

With the accelerated war programs, the lists of mid-year degrees from most of the larger colleges have become long and impressive. This is true not only for the bachelor's degrees but in graduate work as well. At Harvard, for example, 30 Ph.D. degrees were awarded in February, a third of them in the sciences. Among these, three go to astronomers, an unprecedented record for mid-years and close to the all-high record for any Harvard commencement—four in June, 1938.

Meanwhile the neighboring women's college, Radcliffe, which had awarded a total of five Ph.D. degrees in astronomy before 1939, has since added four more.

The three new Harvard degrees go to Lawrence H. Aller, Donald A. MacRae, and Walter O. Roberts. From their theses we see that Dr. Aller is an authority on theoretical astrophysics, especially on the planetary nebulae; Dr. MacRae, on galactic structure; and Dr. Roberts, on solar physics.



Claude B. Carpenter at the door of his observatory.

THIS is a story about Claude B. Carpenter, about his back-yard astronomical observatory, and about some of the work he is doing as an amateur astronomer; for he is an amateur and also an astronomer, in the truest sense of both words.

Mr. Carpenter lives on Chestnut Street, in Wayne, a suburban community somewhat west of Detroit. He is in his early 40's and unmarried. His daytime job is that of a dispatcher of mails in the Wayne post office. His astronomical activities are carried on in the evening and during vacations.

A dozen or so years ago, Claude Carpenter was visiting a friend, and saw for the first time a telescope mirror. It was a small one, four inches in diameter, but

Amateur Astronomers

THE CARPENTER OBSERVATORY

BY CHARLES S. JOHNSON, *Detroit A. S. and Northwest A. A. S.*

it fascinated him. Again and again, he looked into its highly polished magnifying surface. He asked many questions, and saw opening up before him widening horizons of scientific adventure.

The first telescope that Carpenter made was a 10-inch reflector, with a mirror mounted in a sheet-iron tube, and the standard constructed of wood. This was a beginning. Its principal accomplishment was to create a desire for better equipment.

The Detroit Amateur Astronomical Society was organized in 1932. Carpenter became a member and took an active part in its work. In 1939 he was elected its president, and was re-elected in 1940. This society brings together men and women, all interested in astronomy, but with many different specialties, trainings, and backgrounds. At various meetings and informal gatherings of members, Mr. Carpenter repeatedly expressed the wish to build a larger telescope, one designed primarily for photographic work.

The Detroit Astronomical Society was a source of friendly co-operation and assistance. Members with experience in mechanical design and machine tool work helped with the planning and building of the base and the various other mechanical features. The assistance given by Harry Armiger with this part of the work was especially helpful.

Mr. Carpenter, himself, had worked for years as an electrician, before going into the post office. With this background and training he was able to design and execute most of the electrical clock apparatus. It required several

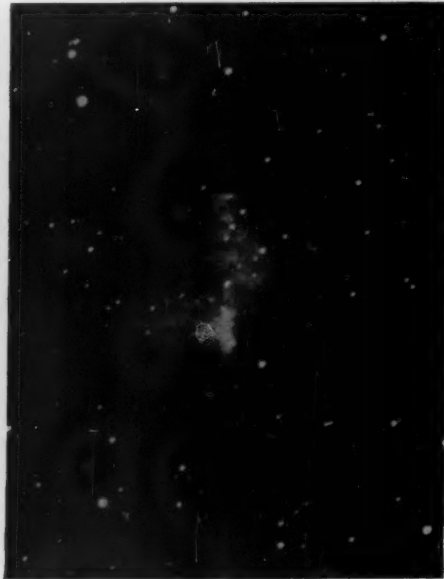
years of persistent spare-time work on the part of himself and his associates, from the time the first plans were considered until the first photograph was completed. As he himself expressed it: "We had to be regular geniuses in meeting and overcoming difficulties." The grinding, polishing, and figuring of the principal mirror were done by Leland S. Barnes, of Waltham, Mass.

The telescope is of double tube construction; each tube is 14 inches in diameter. The longer, which is the telescope proper, has a 12½-inch mirror, of 87 inches focal length. The shorter tube houses a 5½-inch Petzval Voigtlander portrait lens with a focal length of 26 inches. A 5x7-inch photographic plate is used. The central 4x5-inch portion of this plate has a very good field and is capable of being enlarged four or five diameters. There is also an 8½-inch mirror of 75 inches focal length mounted in a flexible tube; with this a Barlow lens is used to increase the effective focal length by about three times.

The right-ascension clock is driven by a synchronous motor, and is differentially geared to electric fast and slow motions. The declination also has fast and slow motions and a hand wheel.

A 6½x9-centimeter camera is used in connection with the 12½-inch mirror. This makes a picture that can at times be enlarged as much as nine diameters. The accompanying photograph of the Ring nebula in Lyra was enlarged eight times.

After the completion of this larger telescope, Claude Carpenter began send-



M13, famous globular cluster in Hercules (left), the Dumbbell nebula in Vulpecula (center), and Lyra's Ring nebula (right), all photographed with the Carpenter telescope. The photos had, respectively, 25 minutes' exposure, 6x enlargement; 22 minutes, 4x; 30 minutes, 8x.

ing observations to the American Association of Variable Star Observers. He also started corresponding with other observers, and frequently attended the annual and semi-annual meetings of astronomical societies. On four occasions, he traveled from his home in Michigan to California, and visited observatories and amateur astronomers en route.

An astronomical lecture accompanied by motion pictures is definitely a rarity. However, Claude Carpenter is glad to meet requests for this type of educational program, as far as his time permits. He begins by showing movies taken at various college observatories, followed by pictures of Mt. Wilson and Mt. Palomar. There are two sets of Palomar pictures. Views of the giant dome in process of construction, with the scaffolding still standing, are first shown, followed by movies taken 14 months later, with the building and dome completed. Pictures made inside the huge structure come next, showing the giant steel girders and huge stairways. Through the camera's photographic eye, persons looking at the pictures climb the stairway vicariously.

After the motion pictures, the lecture

is continued by the showing of 8x10-inch mounted photographs of various well-known astronomical bodies, such as the Andromeda nebula, the cluster in Hercules, the Dumbbell, Orion, and Ring nebulae. A few minutes is spent in discussing and explaining some of the outstanding features of each astronomical object shown, and then the photos are passed around for the personal inspection of interested members of the audience. Mr. Carpenter is very proud of his picture of the Dumbbell nebula, shown here, and regards it as his best work to date.

Claude Carpenter likes to talk about the great difference in observing conditions between Michigan and Southern California. In Michigan, especially in and around Detroit, the observer is beset with many difficulties—an overcast sky most of the time, smoke, fog, and haze, direct and reflected light, and many electric wires. In Southern California he claims that these difficulties are almost non-existent. "With my present 12-inch telescope working under typical Michigan conditions," he said, "I can observe variables at minimum to as low as mag-

The nebula in the sword of Orion, photographed by Mr. Carpenter. The exposure was 25 minutes with a K-2 yellow filter; enlargement, four diameters.

nitude 15.5. However, in California around the vicinity of Lake Elsinore, I can observe the same variables at minimum, but I can do it with an 8-inch portable telescope."

During the visit of Comet Cunningham, Mr. Carpenter was able to take a number of photographs. These plates have been loaned to Mr. Cunningham for his further examination and study.

RITTENHOUSE SOCIETY HONORS MOULTON

Dr. Forest Ray Moulton, whose work in theoretical astronomy and celestial mechanics earned him a prominent place among the astronomers of modern times, was awarded the Rittenhouse Medal and honorary membership in the Rittenhouse Astronomical Society, at the annual joint meeting of the Rittenhouse Society and The Franklin Institute in Philadelphia on March 3rd.

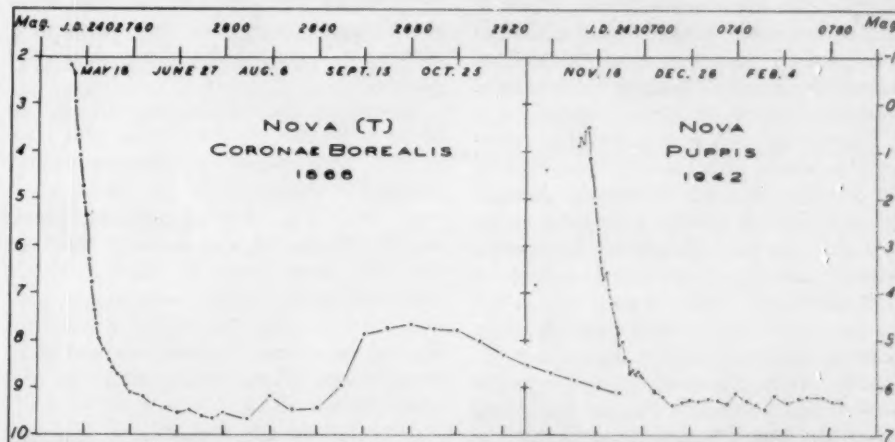
A former co-worker of Dr. Moulton, Dr. Charles P. Olivier, announced that the award was being made "in recognition of Dr. Moulton's eminent contributions to theoretical astronomy, theories of the formation of the solar system, mathematics, ballistics, and his present activities as Permanent Secretary of the American Association for the Advancement of Science."

The presentation was made by Armand N. Spitz, president of the society. Dr. Moulton acknowledged the honor by delivering an address on *Newton, His Influence on Science and Philosophy*.

AMATEUR ASTRONOMERS ASSOCIATION New York City

On April 21st, Dr. L. J. Lafleur, of Barnard College, will speak on *Interplanetary Communications*. This meeting will be at 8:15 p.m. in the American Museum of Natural History, and the public is invited.

The fifth annual dinner of the association is scheduled for April 7th.



The light curve of the latest nova closely resembles that of a nova in 1866.

More About Nova Puppis

Nova Puppis is still in the limelight as an object of interest, especially in the Southern Hemisphere. As with all new stars, we wonder to what class of novae it belongs, or if it will behave as did any previously discovered nova.

We were much thrilled when we noted that Nova Herculis 1934 behaved very much as did Nova Aurigae of 1891. And still more recently, we found that Nova Cygni 1942 was following the pattern set by both Nova Aurigae and Nova Herculis.

Now that four months have elapsed since the discovery of Nova Puppis last November, we find that the visual light curve of Nova (T) Coronae Borealis, discovered in May, 1866, is a very close counterpart of Nova Puppis; the same general rate of decrease after maximum was attained, the same form of round-

ing off and flatness during the next 100 days.

As shown in the diagram above, about six months after maximum, T Coronae began a slow and gradual brightening to a secondary maximum, magnitude 7.7, which lasted for several months, and then the star faded to a magnitude slightly brighter than the 10th. Ever since that time, 1867, it has remained, with slight fluctuations, at that same magnitude.

Will Nova Puppis further follow the course of T Coronae Borealis? Time only can tell. If it remains at or near magnitude 6.0 to 6.5, as it has for the past three months, Nova Puppis may prove to be an object of exceeding interest and easy to observe for many years to come.

LEON CAMPBELL



A unique portrait of the earth's shadow, "seen" during the lunar eclipse in February.
Photo by Peter A. Leavens.

Another Good Eclipse

FOR the second time in succession, after most preceding occasions in recent years had been spoiled by bad weather, clear skies and ideal observing conditions prevailed over most of the United States on the night of February 19-20th, to allow widespread observation of the lunar eclipse. And although it was only 77 per cent total, this eclipse seemed to equal in interest its beautiful predecessor—that of August, 1942.

There were certain advantages in having the moon pass through the edge of the shadow, instead of directly through its center; for instance, it seemed to reveal the size and shape of the earth's shadow more graphically than does a total eclipse. Only during a partial eclipse can lunar photographs such as those collectively shown above be obtained. They illustrate how large the earth's shadow really is at the place where the moon passes through it. The three exposures were made at intervals of one hour, beginning at 12:30 a.m., when the partial phase was half an hour under way. The central image was taken practically at mid-eclipse, and the

last (on the left) at 2:30 a.m. They are placed to show as closely as possible the actual motion of the moon through the earth's shadow, and in a direction about 15 degrees south of east. Irregularities in the outline of the umbra are caused in part by the darkness of the lunar maria and partly by the penumbra, which is particularly dark near the umbra.

Attesting the diminution of moonlight, even though the eclipse was only partial, were naked-eye observations of Whipple's comet made by many amateurs not long after the partial phase began. Earlier in the evening, Regulus and the moon were in close conjunction, binoculars being necessary to pick out the star near the bright moon, but during the eclipse, the star became quite conspicuous along with others in the constellation of Leo.

On the whole, the eclipse did not seem as colorful as that of last August, perhaps because the moon did not dip deep into the ruddy umbra. Nevertheless, many observers did report colors. Oscar E. Monnig, editor of the Texas Observers' *Bulletin*, describes the presence of a "pink" color on the dark part of the moon. He saw no green, but did observe a "slaty blue" which another observer called "slate green." He remarked on the shadow edge being especially clean-cut when compared to other eclipses. Robert E. Slovensky, of Cleveland, Ohio, who took some snapshots of the eclipse, noted also the "deep bluish-green color" of the edge of the umbra.

As usual, members of the Amateur Astronomers Association in New York photographed the eclipse from Ocean-side, L. I., where their 10-foot camera (images above are practically contact size) was mounted as shown in the photograph at the left. The lad on the scaffold probably hopes the next eclipse is near the horizon!



The altitude of the moon necessitated pointing the long-focus camera high in the sky. Nassau Daily "Review-Star" photo.

AN ENGLISHMAN THE T

A. P. HERBERT, the senior member of Parliament for Oxford University, on the occasion of being confined to bed with a bad foot, patiently went over the entire sky and altered the ancient configurations in favor of new groups with modern connotations and representations. He has named a large number of stars, including some which do not have currently used names, and claims that his system enables "the airman or the seaman to find the way from constellation to constellation, and from star to star, not by painful feats of memory or calculation, but by simple processes of thought and association."

To anyone who even briefly peruses Mr. Herbert's new star chart of the entire heavens, originally published in *The Illustrated London News* of December 26, 1942, the humor of his effort is at once apparent. His reputation as a jester and reformer may perhaps excuse his proposal in the eyes of those who refuse to take any such change seriously. And, as he points out in the article accompanying the chart, there are many reasons why such a change would actually benefit mankind, although, as he says himself, no star designations may be expected to last forever.

A portion of his chart containing some well-known constellations is reproduced here, and we quote parts of his article which may be of particular interest to readers of *Sky and Telescope*:

"I started from scratch, or very nearly; that is, like most of us, I could name and find one or two constellations, and two or three stars, with luck. But now I can claim proudly that I have in my mind a clear map of the whole heavens

"The Great Bear—or rather, the seven chief stars which most of us know—is not like a bear, but like a plough or a saucepan (and indeed the Americans flipantly but sensibly call it The Dipper)

"Now I wish that astronomers would come together and say, 'Let us have done with all this unworthy stuff . . . these old names are hindering the spread of knowledge and hiding the glory of the stars

"And now I suggest, with all proper humility and apology, the kind of way in which the job might be done. Take, for example, Orion, the finest constellation, the favourite of the sailor who, like the sailor, is not always with us in these islands, but sinks beyond the horizon in May and returns in November to delight us. Suppose that Orion be named The Sailor and the great star

HUMAN RENAMES THE STARS

Betelgeuse be christened Nelson and Rigel Drake, Bellatrix Hawkins, Saiph Magellan, and the three stars of the Belt be called Cook, Columbus and Cabot, and the sword star Vasco da Gama. Then indeed will that constellation have a meaning for the mariner; and the children, being told that those two bright stars are Nelson and Drake—not Betelgeuse and Rigel—will be eager to know more, for their minds will touch the good deeds of man as well as the great works of Heaven.

"... under the New Order you will know that a certain large section of the sky is occupied by The Men of Mind, and if you recognize the trio Beethoven, Bach, and Brahms, you will say, 'Ah, then that star to the right must be one of the poets—and the two stars below them must be Story-Tellers or Painters.'

"About the details, the choice of names for the seven Great Britons [in the Big Dipper] or the thirteen poets worthy to have a star, anybody's bet is as good as mine; and I shall not argue much. Indeed, I hope that everyone will argue the point, not only with me but with each other. For, as I have found, this



The sky from Scorpion to Pegasus and Cygnus—a portion of A. P. Herbert's modernized star chart, reproduced from the original in "The Illustrated London News."

is a good way to learn not only about the stars of Heaven but the story of the Earth... if you are allotted 13 of the heavenly bodies and are told that to

these, and no more, you may attach the names of thirteen poets, the problem becomes, believe me, both stimulating and instructive...

A Graphical Determination of Pi

BY CARL A. HELLMANN

National Capital Amateur Astronomers Association

A METHOD which may be of use in some wartime mathematical and geometrical problems and which may save time and avoid mistakes in calculations, by serving as a check on the results of arithmetical computations, is illustrated by the accompanying diagrammatic example. It is a simple graphical method whereby the length of the circumference of a circle can be represented by a straight line, with a reasonable degree of accuracy, and without involving any complicated measurement or diagram.

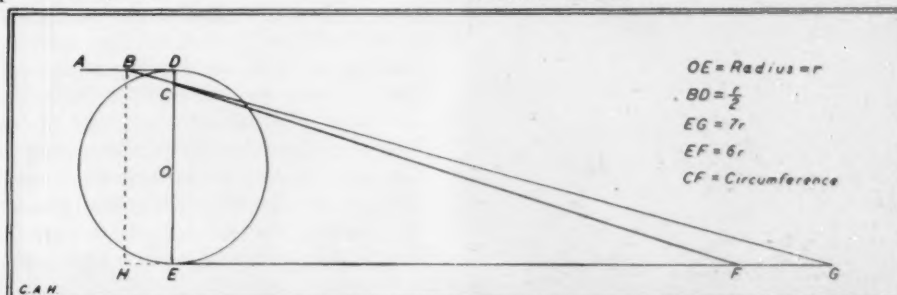
The only instruments required are the compass with which the circle itself is drawn and a straightedge with which a diameter is ruled—the straightedge may even be ungraduated. The final result can be taken directly from the drawing by dividers, with an error for a 20-inch circle of less than 1/200 of an inch, closer than the figure can be drawn with ordinary drafting instruments, and quite close enough for practically all shop purposes. This is as good or better than could be done from a machinist's scale, ordinarily graduated into 1/100 of an inch divisions.

Referring to the diagram, to find the circumference of the circle whose center is at O, and whose radius is OE, draw tangents at both ends of the vertical diameter, DE, extending in opposite directions, as shown. Lay off the radius, OE, seven times along one tangent, to the point G, and also lay off the radius once on the other tangent, to the point A. Bisect AD to get point B, and connect B and G with the straight line BG, which intersects DE at point C. Starting from G, lay off the radius once back along GE to locate point F. Connect F and C with a straight line CF, which is equal in length to the circumference of the circle with an accuracy better than one part in 12,000.

The length of CF corresponds to a value of π of 3.141832+, which may be compared with the true value of 3.141592+, so a 20-inch circle would have a graphical circumference too large by less than 0.005 inches.

It is believed that an important advantage of this method is that all errors of computation are avoided, as no measurements need be made and no graduated straightedge is required.

EDITOR'S NOTE: The proof is very simple. The sides BH and CE in the triangles BHG (partially dotted lines in the diagram) and CEG are proportional to HG and EG, respectively. Since EG is 7 times the radius, HG is $7\frac{1}{2}r$, therefore CE is $14/15$ of $2r$. This is one side of the right-angled triangle CEF, and the other side is $6r$; the sum of their squares is $8884/225$ or 39.48444444 ... and its square root is 6.283664 +. The circumference is $2\pi r$, or $6.283184r$, so that for a radius of 10 inches the difference is 0.0048 inches.



WEATHER SIGNS IN THE SKY

BY WILLIAM H. BARTON, JR.

Some of the old weather signs that men have used for long ages are reviewed here, and they have their part in the Hayden Planetarium story this month.

1435E WA C45 • 07R-119/63/56+3/988

THIS is a weather sign, not a coded message to tell you where to dig for buried treasure. You cannot read it? It's easy. It is what a weather report looks like on the teletype. "At 2:35 p.m. Eastern standard time at Washington, D. C., the conditions at the airports were suitable for contact flying. The ceiling was 4,500 feet. There was an overcast but under it broken clouds. The visibility was seven miles and there was light rain. The barometer read 1011.9 millibars pressure. The temperature was 63° F. and the dewpoint was 56°. A south wind of three miles an hour was blowing and the plane's altimeter on the ground should read 29.88 inches."

That is a modern weather sign, one of interest to an aviator. Such information is of great help to the enemy and therefore today we keep it secret. Long before there were ceilings, contact flying, millibars, and altimeters, there were weather signs—but they were not read from teletype sheets. They were read from the sky. They were not read by pilots in fantastic flying suits but by farmers, mariners, in fact, by almost anybody. They told, not what conditions prevailed some place at a distance, but what they would be where the ob-

Praesepe, the Manger, in Cancer.

server was at a time in the future. In the sky we can sometimes see forecasts—at least in a general way.

People frequently confuse astronomy and meteorology. It is true that our weather is made on the sun. The sun evaporates the water from the ocean to form clouds and vapor in the atmosphere. The sun makes the winds blow by warming the ground and ocean and these in turn warm the earth's atmosphere and cause it to move. The common element in these statements, you see, is atmosphere, the air surrounding the earth. Meteorology is the study of that atmosphere.

It is through the air that we see the stars. Therefore changes in the air affect the "seeing" and that is the source of the ancient belief that we can forecast the weather by the appearance of the sky. The air does things to the light from the sun, moon, and stars. Old-time weather forecasting consisted somewhat in interpreting these signs.

Also, weather is somewhat dependent on the season, and the stars come and go with the seasons. Therefore, certain stars were indicators of the coming of certain kinds of weather.

But in the old days there were many other signs that told the weather, as this poem from Chambers' *Book of Days* (1863) attests:

SIGNS OF FOUL WEATHER

By Dr. Erasmus Darwin

*The hollow winds begin to blow;
The clouds look black, the glass is low;
The soot falls down, the spaniels sleep;
And spiders from their cobwebs peep.
Last night the sun went pale to bed;
The moon in halos hid her head.
The boding shepherd heaves a sigh,
For, see, a rainbow spans the sky.
The walls are damp, the ditches smell,
Clos'd is the pink-ey'd pimpernel.
Hark! how the chairs and tables crack,
Old Betty's joints are on the rack:
Her corns with shooting pains torment her,
And to her bed untimely sent her.
Loud quack the ducks, the sea fowl cry,
The distant hills are looking nigh.
How restless are the snorting swine!
The busy flies disturb the kine.
Low o'er the grass the swallow wings,
The cricket, too, how sharp he sings!
Puss on the hearth, with velvet paws,
Sits wiping o'er her whisker'd jaws.
The smoke from chimneys right ascends,*

Then spreading, back to earth it bends.

*The wind unsteady veers around,
Or settling in the South is found.
Through the clear stream the fishes rise,*

*And nimbly catch the incautious flies.
The glow worms num'rous, clear and bright,*

*Illum'd the dewy hill last night.
At dusk the squalid toad was seen,
Like quadruped, stalk o'er the green.
The whirling wind the dust obeys,
And in the rapid eddy plays.*

*The frog has chang'd his yellow vest,
And in a russet coat is drest.*

*The sky is green, the air is still,
The mellow blackbird's voice is shrill.
The dog so alter'd in his taste,*

*Quits mutton-bones, on grass to feast.
Behold the rooks, how odd their flight,
They imitate the gliding kite,
And seem precipitate to fall,*

*As if they felt the piercing ball.
The tender colts on back do lie,
Nor heed the traveller passing by.
In fiery red the sun doth rise,
Then wades through clouds to mount the skies.*

'Twill surely rain, we see't with sorrow,

No working in the fields tomorrow.

"Last night the sun went pale to bed," probably because clouds were gathering in the west, cirrus clouds, most likely. These are composed of ice crystals high in the air dimming out objects beyond, and even making rings around the sun or moon: "The moon in halos hid her head." The tiny falling raindrops sometimes break up sunlight into its component colors and "a rainbow spans the sky."

Sometimes, when moisture has collected in the atmosphere it acts like a screen that separates the long and short waves of light. Through such a screen the sun appears red in the morning. That is, "In fiery red the sun doth rise, then wades through clouds to mount the skies." There is another perhaps better-known jingle that says the same thing:

*Evening red, morning gray,
Sets the traveler on his way.
Evening gray, morning red,
Keeps the traveler in his bed.*

Such weather signs are not infallible but they do give a fair indication of things to come.

In the past, the moon has been held responsible for many weather changes,

ASTRONOMICAL ANECDOTES

PTOLEMY'S STAR CATALOGUE

LAST month this department was concerned with Bayer's *Uranometria*, published in 1603. The so-called Planisphere of Geruvigus, mentioned then, dates from at least the 9th or 10th century A.D., and not the 2nd, as stated. This later date does not alter the point made there, that others before Bayer had shown the inside surface of the sky, as it is seen from the earth.

Another comment has come to me from Dr. S. G. Barton, of the University of Pennsylvania, concerning the connection of Dürer with the pictures in the *Uranometria*. In Allen's *Star Names and Their Meanings*, pages 28 and 29, we find that according to Thausing's *Life of Dürer* the great engraver did make a set of constellation pictures about 1515,

although its actual influence is very small. We know the moon is the chief cause of tides. There is an old saying that "showers are more frequent at the turn of the tide," which some think is a result of the moon's influence. If there is an appreciable drop in the barometer, and there always is when a low-pressure area comes, the higher pressure elsewhere may cause a false tide, an influx of water of more than a foot at times, when no tide is due. But this same "low" often brings rain. The tide referred to is not a lunar tide at all, but a barometric phenomenon.

The appearance of the moon may indicate the atmospheric conditions. All astronomical observers are aware of the different degrees of "seeing." When the air is in motion (turbulence), the atmospheric layers of unequal temperature are continually mixing, and that causes twinkling of the stars and a somewhat fuzzy edge on the moon. However, this same turbulence carries ground haze and dust particles high into the air and scatters them, so a clear sky prevails.

Aratos in his famous *Phaenomena* tells us to:

*Watch the manger like a little mist
Far north in Cancer's territory it floats.
Its confines are two faintly glimmering
stars;*

*There are two asses that a manger
parts.*

*Which suddenly when all the sky is
clear*

*Sometimes quite vanishes, and the two
stars*

*Seem to have closer moved their
sundered orbs.*

*No feeble tempest then will soak the
leas;*

*A murky manger with both stars
Shining unaltered is a sign of rain.*

Yes, there are weather signs in the sky—if you can read them.

which were used to illustrate an edition of Ptolemy's catalogue in star map form. Thausing says, "These constellation figures of Dürer, with but few changes, have been copied by Bayer . . . , Flamsteed . . . , Argelander . . . , and Heis" I doubt very much that either Thausing or Allen had the various books before them for comparison. Certainly if we want to consider as a "copy" a picture that has Capricornus facing west, and Taurus facing east, they are all copies. But Flamsteed's pictures differ in style, texture, and detail from Bayer's, and the others differ as well. In that sense, practically everyone, Dürer included, copied from the Farnese Atlas-globe, and the ideas of Hyginus.

Sometime we must return to Bayer, but in the meanwhile we shall go back to Claudius Ptolemaeus, the Alexandrian Greek astronomer and geographer, and his most famous work, *Megale Syntaxis*. Think of him as Ptolemy, if you like, and of his work by the familiar contraction, *Almagest*, from the Arabs' name for it. In the seventh and eighth books of this work, Ptolemy gave us the oldest surviving star catalogue, containing 1,028 entries.

It is to the Arabs that we owe the preservation of the *Almagest*. Many of the Arab versions of the catalogue have vanished, of course, but the earliest we have is the catalogue of Aboul Hassan, who listed 240 stars of Ptolemy's catalogue, reduced to the year 622 A.D. Two versions of Ptolemy's full catalogue were prepared at Bagdad, the first by abu-Jafar Almansur (who died in 775 A.D.), the predecessor of the Caliph Harun-al-Rashid, the second by al-Mamun (who died in 833 A.D.), the son of the great Caliph.

Gerard of Cremona (1114-1187 A.D.) made some curious errors in his Arabic version, because apparently he learned his Arabic from the Moors, and there are several important differences between the Maghribi or African Arabic and the Neshki or usual Eastern Arabic. Some of his star latitudes are given as 300-odd degrees, instead of 60-odd, because the Western Arabic character for 300 is identical with the Eastern character for 60, and Gerard of Cremona knew nothing about astronomy.

From this Arabic version, at least two Latin translations were printed, by Copernicus and Liechtenstein. Other Latin versions were published, one in the Alphonsine Tables from the Arabic, and several from the Greek, particularly by Flamsteed, Trapezuntius, and Schreckenfuchs. There are at least six Greek editions in print, those of Grynæus, Halley, Montiguot, Halma, Baily, and Heiberg.

No less than 55 codices or manu-

scripts were consulted by C. H. F. Peters and Edward Ball Knobel in the preparation of their modern edition (*Publication No. 86 of the Carnegie Institution of Washington*, 1915): "Ptolemy's Catalogue of Stars; A Revision of the *Almagest*." It is a very careful work, and very important because the catalogue of Ptolemy is the only one compiled between A.D. 138 and 1437, when Mirza Ulugh Beg bin Shakrukh bin Timur Kurgan (usually known as Ulugh Bey), with the assistance of Ali bin Muhammed Kushji, carried to completion the original catalogue of observations begun by Sala'h ud-Din Musa (or Kazi-Zadah Rumi) and Ghiyas ud-Din Jamshid. The next catalogue was that of Tycho, published in 1602.

Always of importance in connection with Ptolemy is the question of the originality of the catalogue contained in the *Almagest*. About 130 B.C., Hipparchus had compiled a commentary on the *Phaenomena* of Aratos, a description of the sky in verse. In this, Hipparchus incorporated the observations of star positions by Timocharis and Aristillus, completing the catalogue with his own observations. It was he who discovered precession, by noting the departure of his star positions from those of the earlier observers; he gave the value of 35 seconds of arc per year for the constant of precession, and this is 30 per cent too small.

This fact is significant, for it appears that Ptolemy probably applied this smaller value of the precession in changing Hipparchus' star positions by the 267 years intervening between 130 B.C., the epoch of Hipparchus, and 138 A.D., the epoch of Ptolemy. Applying 35 seconds of arc per year for this interval yields $2^{\circ} 36'$, whereas the actual value should have been $3^{\circ} 44'$ for the precession in longitude, as we now know. But Ptolemy did not—he stated that his longitudes and those of Hipparchus differed by $2^{\circ} 40'$. In the *Almagest*, he lauds Hipparchus for his work, but he leads one to infer that Ptolemy himself made the observations represented by his catalogue, for which he gives as the epoch "the first year of Antoninus Pius," or 138 A.D. But the star positions in his catalogue, checked by our modern precession constant, are those of 58 A.D., or 80 years before Ptolemy!

This discrepancy led Prof. Peters to speak of "the catalogue of stars by Hipparchus transmitted to us by Ptolemy," and Knobel said, "Notwithstanding Ptolemy's statement that he 'observed as many stars as it was possible to perceive, even to the sixth magnitude,' . . . the catalogue is in all probability that of Hipparchus reduced by the addition of a constant to the longitudes, and retaining his original latitudes. The descriptions of the stars were probably amended by Ptolemy." R.K.M.



● "The mirrors were entrusted to The Perkin-Elmer Corporation. Our specifications were exacting, as no part of any surface could depart from the theoretical surface by more than one-tenth of a standard wavelength... Perkin-Elmer Corporation completed the primary mirror by conventional methods... It was then tested, pronounced well within the specifications, and found to have an unusually fine surface. The two high magnification secondaries, however, presented real difficulties. McCarthy, of Perkin-Elmer, felt that conventional methods of testing were inadequate and proposed a new method, which he has recently described. The Perkin-Elmer Corporation made up the necessary auxiliary optical equipment, and our two secondaries were figured by the new method, which eliminates the combined testing of primary and secondary. These two mirrors have been an unqualified success, both focal lengths being well within specifications, while the figuring is superb. Exposures for the disk of Jupiter are shorter by a factor of at least twelve when compared with our old 10½-inch telescope."

From Volume VIII, No. 6, Publications of The Observatory of The University of Michigan describing the Francis C. McMath Memorial 24-inch Reflecting Telescope, now in operation at the McMath-Hulbert Observatory of the University of Michigan.



GLEANINGS FOR A. T. M.s

DESIGNING AN ACHROMATIC OBJECTIVE—V

(Continued from the February issue)

10. Ray Tracing for Chromatic Aberration and Spherical Aberration: We are now ready to trace rays and to determine chromatic and spherical aberration by tracing paraxial rays in N_c and N_e , and marginal and paraxial rays in N_d . Our computation sheet appears as Table IV, taking our entering rays parallel to the axis.

Our first computation gives us spherical aberration of -0.024 , and chromatic aberration of -0.515 . We now trace our four rays through the last surface only, using radii of $100.000''$ and $-100.000''$, to establish a curve. Our results (Table V) give us chromatic aberration as follows, for the last surface only:

| Radius | Curvature | Chr. A. |
|-----------|-----------|----------|
| Infinity | 0 | + 2.118" |
| 100.000" | .01 | -18.505" |
| -100.000" | -.01 | 3.095" |

We make a graph with these three values of curvature and chromatic aberration, and sketch in a rough curve. The value we want is $+2.633$, the chromatic aberration at the second surface being -2.633 . This will be found to be approximately at curvature $-.0027$, corresponding to a radius of $-370.000''$. We consider only chromatic aberration here. It would be useless to deal with both chromatic and spherical aberration at this point, as their desired values would not correspond.

Now we trace our four rays through the

last surface (Table VI), using the radius $-370.000''$, and find: chromatic aberration $= -.001''$; spherical aberration $= .065''$.

Seven-place logs are used from here on, for greater accuracy. We must now decide how much of each of these aberrations is permissible in our lens. Conrady gives the following as tolerances for sharp definition:

Chromatic: 1 wave length $/N'\sin^2 U'_m$

Spherical: 4 wave lengths $/N'\sin^2 U'_m$

These tolerances are based upon the Rayleigh limit and the physical character of optical images, which is beyond the scope of this article, so we shall accept the tolerances as stated.

One wave length (yellow) is 6×10^{-5} cm. or $.000024''$; N' is $0.20871''$, and U'_m is about 2° . This gives tolerances as follows: chromatic aberration $= 0.014''$; spherical aberration $= 0.056''$.

The spherical aberration in the computation above is too great, although the chromatic is well within the tolerance. So we must make a slight change in curvature to bring the spherical in line, if we can do so without changing the chromatic beyond limits. Let us try a radius on the last surface of $-365.000''$. The computation works out as in Table VI: chromatic aberration $= 0.006''$; spherical aberration $= -0.005''$.

It is conceivable that further adjustments of radii might yield values lower than these, but these are well within the tolerances stated. Now, if the lens will survive tests

Table IV

| COMPUTATION SHEET | | | | | | | | | | | | |
|--------------------|----------|-------------|----------|-----------------|--------------|--------------|--------------|-------------------------|-----------------|--------------|--------------|--|
| Y = 3" | | | | FIRST SURFACE | | | | SECOND SURFACE | | | | |
| $r_1 = 53.100''$ | | | | $N_d = 1.57250$ | | | | $r_2 = -30.177''$ | $N_d = 1.61700$ | | | |
| | | | | $N_c = 1.56956$ | | | | | $N_c = 1.61218$ | | | |
| | | | | $N_f = 1.57953$ | | | | | $N_f = 1.62904$ | | | |
| | | | | N_d Marg. | N_d Parax. | N_c Parax. | N_f Parax. | N_d Marg. | N_d Parax. | N_c Parax. | N_f Parax. | |
| L | -- | -- | -- | -- | -- | -- | -- | 144.960 | 145.067 | 145.557 | 143.940 | |
| -r | -- | -- | -- | -- | -- | -- | -- | 30.177 | 30.177 | 30.177 | 30.177 | |
| L-r | -- | -- | -- | -- | -- | -- | -- | 175.137 | 175.244 | 175.734 | 174.117 | |
| log (L-r) | -- | -- | -- | -- | -- | -- | -- | 2.24338 | 2.24364 | 2.24486 | 2.24084 | |
| +log sin U | -- | -- | -- | -- | -- | -- | -- | 8.31373 | 8.31323 | 8.31175 | 8.31660 | |
| log (L-r) sin U(Y) | 0.47712 | same | same | same | same | same | same | 0.57711 | 0.55687 | 0.55661 | 0.55744 | |
| log r | 1.72509 | same | same | same | same | same | same | 1.47968n | 1.47968n | 1.47968n | 1.47968n | |
| log sin I | 8.75203 | same | 8.75203 | 8.75203 | 8.75203 | 8.75203 | 8.75203 | 9.07743n | 9.07719n | 9.07693n | 9.07776n | |
| +log N/N' | -0.19659 | same | -0.19578 | -0.19578 | -0.19578 | -0.19578 | -0.19578 | -0.01212 | -0.01212 | -0.01163 | -0.01340 | |
| log sin I' | 8.55544 | same | 8.55625 | 8.55350 | 8.55350 | 8.55350 | 8.55350 | 9.06531n | 9.06507n | 9.06530n | 9.06436n | |
| +log r | 1.72509 | same | 1.72502 | 1.72502 | 1.72502 | 1.72502 | 1.72502 | 1.47268n | 1.47268n | 1.47268n | 1.47268n | |
| log r sin I' | 0.28053 | 0.28053 | 0.28134 | 0.27859 | 0.27859 | 0.27859 | 0.27859 | 0.54499 | 0.54475 | 0.54498 | 0.54404 | |
| -log sin U' | 8.31373 | 8.31323 | 8.31175 | 8.31660 | 8.31660 | 8.31660 | 8.31660 | 8.23761 | 8.23754 | 8.23930 | 8.23274 | |
| log (L'-r) | 1.96680 | 1.96730 | 1.96959 | 1.96199 | 1.96199 | 1.96199 | 1.96199 | 2.30738 | 2.30721 | 2.30568 | 2.31130 | |
| U | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1-10-48 | .02057 | .02050 | .02073 | |
| +I | 3-14-20 | -.05650 | -.05650 | -.05650 | -.05650 | -.05650 | -.05650 | -6-51-51 | -.11945 | -.11938 | -.11961 | |
| U+I | 3-14-20 | .05650 | .05650 | .05650 | .05650 | .05650 | .05650 | -5-41-03 | -.09888 | -.09888 | -.09888 | |
| -I' | 2-03-32 | -.03593 | -.03600 | -.03577 | -.03577 | -.03577 | -.03577 | 6-40-28 | .11616 | .11623 | .11597 | |
| U' | 1-10-48 | -.02057 | -.02050 | -.02073 | -.02073 | -.02073 | -.02073 | 0-59-25 | -.01728 | -.01735 | -.01709 | |
| L'-r | 92.640 | 92.747 | 92.737 | 91.620 | 91.620 | 91.620 | 91.620 | 202.946 | 202.866 | 202.153 | 204.786 | |
| tr | 53.100 | 53.100 | 53.100 | 53.100 | 53.100 | 53.100 | 53.100 | -30.177 | -30.177 | -30.177 | -30.177 | |
| L' | 145.740 | 145.847 | 146.337 | 144.720 | 144.720 | 144.720 | 144.720 | 172.769 | 172.689 | 171.976 | 174.609 | |
| -d | -.780 | -.780 | -.780 | -.780 | -.780 | -.780 | -.780 | -.500 | -.500 | -.500 | -.500 | |
| L ₁ | 144.960 | 145.067 | 145.557 | 143.940 | 143.940 | 143.940 | 143.940 | 172.269 | 172.189 | 171.476 | 174.109 | |
| THIRD SURFACE | | | | | | | | | | | | |
| | | | | N_d Marg. | | | | $r_3 = \text{infinity}$ | $N' = 1.00000$ | | | |
| log sin U | 8.23761 | log L | 2.23621 | N_d Marg. | | | | log L | N_d Parax. | N_c Parax. | N_f Parax. | |
| +log N/N' | 0.20871 | +log tan U | 8.23768 | | | | | -log N/N' | 0.20871 | 0.20741 | 0.21193 | |
| log sin U' | 8.44632 | log L tan U | 0.47389 | | | | | log L' | 2.02730 | 2.02679 | 2.02889 | |
| L' | 106.512 | -log tan U' | 8.44649 | | | | | L' | 106.488 | 106.363 | 106.874 | |
| | | log L' | 2.02740 | | | | | | | | | |

EDITED BY EARLE B. BROWN

for coma and astigmatism, our work is done. It is purely good fortune that our correction worked out this way. If it had not, the values obtained for the aberrations would have given a clue as to the direction to go in further slight adjustments. If it

had proved impossible to bring the spherical aberration within limits without introducing intolerable chromatic, we should have had to go back and change all the radii in the lens, maintaining, however, the same ratio of curvatures of crown to flint.

It is now time to check for coma and astigmatism.

(Next installment in June)

Table V

| COMPUTATION SHEET -- Correction No. 1 and No. 2 | | | | | | | | | | | | | | | |
|---|-------------|--------------|--------------|--------------|-------------|--------------|--------------|---------------------------|-------------|--------------|--------------|--------------|-------------|--------------|--------------|
| No. 1: $r_4 = 100.000''$ | | | | | | | | No. 2: $r_4 = -100.000''$ | | | | | | | |
| | N_d Marg. | N_d Parax. | N_c Parax. | N_f Parax. | N_d Marg. | N_d Parax. | N_c Parax. | N_f Parax. | N_d Marg. | N_d Parax. | N_c Parax. | N_f Parax. | N_d Marg. | N_d Parax. | N_c Parax. |
| L | 172.269 | 172.189 | 171.476 | 174.109 | 172.269 | 172.189 | 171.476 | 174.109 | 172.269 | 172.189 | 171.476 | 174.109 | 172.269 | 172.189 | 171.476 |
| -r | -100.000 | -100.000 | -100.000 | -100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |
| L-r | 72.269 | 72.189 | 71.476 | 74.109 | 72.269 | 72.189 | 71.476 | 74.109 | 72.269 | 72.189 | 71.476 | 74.109 | 72.269 | 72.189 | 71.476 |
| log (L-r) | 1.85895 | 1.85847 | 1.85416 | 1.86987 | 2.43500 | 2.43487 | 2.43373 | 2.43792 | 2.43500 | 2.43487 | 2.43373 | 2.43792 | 2.43500 | 2.43487 | 2.43373 |
| +log sin U | 8.23761 | 8.23754 | 8.23930 | 8.23274 | 8.23761 | 8.23754 | 8.23930 | 8.23274 | 8.23761 | 8.23754 | 8.23930 | 8.23274 | 8.23761 | 8.23754 | 8.23930 |
| log (L-r) sin U | 0.09656 | 0.09601 | 0.09346 | 0.10261 | 0.67261 | 0.67241 | 0.67303 | 0.67066 | 0.67261 | 0.67241 | 0.67303 | 0.67066 | 0.67261 | 0.67241 | 0.67303 |
| -log r | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 |
| log sin I | 8.09656 | 8.09601 | 8.09346 | 8.10261 | 8.67261 | 8.67241 | 8.67303 | 8.67066 | 8.67261 | 8.67241 | 8.67303 | 8.67066 | 8.67261 | 8.67241 | 8.67303 |
| +log N N' | 0.20871 | 0.20871 | 0.20741 | 0.21193 | 0.20871 | 0.20871 | 0.20741 | 0.21193 | 0.20871 | 0.20871 | 0.20741 | 0.21193 | 0.20871 | 0.20871 | 0.20741 |
| log sin I' | 8.30527 | 8.30472 | 8.30087 | 8.31454 | 8.88132 | 8.88112 | 8.88044 | 8.88259 | 8.88132 | 8.88112 | 8.88044 | 8.88259 | 8.88132 | 8.88112 | 8.88044 |
| +log r | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 | 2.00000 |
| log r sin I' | 0.30527 | 0.30472 | 0.30087 | 0.31454 | 0.88132 | 0.88112 | 0.88044 | 0.88259 | 0.88132 | 0.88112 | 0.88044 | 0.88259 | 0.88132 | 0.88112 | 0.88044 |
| -log sin U' | 7.98114 | 7.98137 | 7.98945 | 7.96047 | 8.66610 | 8.66558 | 8.66455 | 8.66792 | 8.66610 | 8.66558 | 8.66455 | 8.66792 | 8.66610 | 8.66558 | 8.66455 |
| log (L'-r) | 2.32413 | 2.32335 | 2.31142 | 2.35407 | 2.21522 | 2.21554 | 2.21589 | 2.21467 | 2.21522 | 2.21554 | 2.21589 | 2.21467 | 2.21522 | 2.21554 | 2.21589 |
| U | 0.59-25 | .01728 | .01735 | .01709 | 0.59-25 | .01728 | .01735 | .01709 | 0.59-25 | .01728 | .01735 | .01709 | 0.59-25 | .01728 | .01735 |
| +I | 0.42-46 | -.01247 | -.01240 | -.02167 | -2.41-50 | -.04703 | -.04710 | -.04685 | -2.41-50 | -.04703 | -.04710 | -.04685 | -2.41-50 | -.04703 | -.04710 |
| U+I | 1.42-21 | .02975 | .02975 | .02976 | -1.42-25 | -.02975 | -.02975 | -.02976 | -1.42-25 | -.02975 | -.02975 | -.02976 | -1.42-25 | -.02975 | -.02975 |
| -I' | 1.09-26 | -.02017 | -.01999 | -.02063 | 4.21-50 | -.07605 | -.07594 | -.07631 | 4.21-50 | -.07605 | -.07594 | -.07631 | 4.21-50 | -.07605 | -.07594 |
| U' | 0.32-55 | -.00958 | -.00976 | -.00913 | 2.39-25 | -.04630 | -.04619 | -.04655 | 2.39-25 | -.04630 | -.04619 | -.04655 | 2.39-25 | -.04630 | -.04619 |
| L'-r | 210.926 | 210.548 | 204.842 | 225.980 | 164.142 | 164.263 | 164.396 | 163.934 | 210.926 | 210.548 | 204.842 | 225.980 | 164.142 | 164.263 | 164.396 |
| r | 100.000 | 100.000 | 100.000 | 100.000 | -100.000 | -100.000 | -100.000 | -100.000 | 100.000 | 100.000 | 100.000 | 100.000 | -100.000 | -100.000 | -100.000 |
| L' | 310.926 | 310.548 | 304.842 | 325.980 | 64.142 | 64.263 | 64.396 | 63.934 | 310.926 | 310.548 | 304.842 | 325.980 | 64.142 | 64.263 | 64.396 |

Table VI

| COMPUTATION SHEET -- Correction No. 3 and No. 4 | | | | | | | | | | | | | | | |
|---|-------------|--------------|--------------|--------------|-------------|--------------|--------------|---------------------------|-------------|--------------|--------------|--------------|-------------|--------------|--------------|
| No. 3: $r_4 = -370.000''$ | | | | | | | | No. 4: $r_4 = -365.000''$ | | | | | | | |
| | N_d Marg. | N_d Parax. | N_c Parax. | N_f Parax. | N_d Marg. | N_d Parax. | N_c Parax. | N_f Parax. | N_d Marg. | N_d Parax. | N_c Parax. | N_f Parax. | N_d Marg. | N_d Parax. | N_c Parax. |
| L | 172.269 | 172.189 | 171.476 | 174.109 | 172.269 | 172.189 | 171.476 | 174.109 | 172.269 | 172.189 | 171.476 | 174.109 | 172.269 | 172.189 | 171.476 |
| -r | 370.000 | 370.000 | 370.000 | 370.000 | 365.000 | 365.000 | 365.000 | 365.000 | 370.000 | 370.000 | 370.000 | 370.000 | 365.000 | 365.000 | 365.000 |
| L-r | 542.269 | 542.189 | 541.476 | 544.109 | 537.269 | 537.189 | 536.476 | 539.109 | 542.269 | 542.189 | 541.476 | 544.109 | 537.269 | 537.189 | 536.476 |
| log (L-r) | 2.7342148 | 2.7341507 | 2.7335792 | 2.7356859 | 2.7301918 | 2.7301271 | 2.7295503 | 2.7316766 | 2.7342148 | 2.7341507 | 2.7335792 | 2.7356859 | 2.7301918 | 2.7301271 | 2.7295503 |
| +log sin U | 8.2376128 | 8.2375437 | 8.2392995 | 8.2327421 | 8.2376128 | 8.2375437 | 8.2392995 | 8.2327421 | 8.2376128 | 8.2375437 | 8.2392995 | 8.2327421 | 8.2376128 | 8.2375437 | 8.2392995 |
| log (L-r) sin U | 0.9718276 | 0.9716944 | 0.9728787 | 0.9684280 | 0.9678046 | 0.9676708 | 0.9688498 | 0.9644187 | 0.9718276 | 0.9716944 | 0.9728787 | 0.9684280 | 0.9678046 | 0.9676708 | 0.9688498 |
| -log r | 2.5682017 | 2.5682017 | 2.5682017 | 2.5682017 | 2.5622929 | 2.5622929 | 2.5622929 | 2.5622929 | 2.5682017 | 2.5682017 | 2.5682017 | 2.5682017 | 2.5622929 | 2.5622929 | 2.5622929 |
| log sin I | 8.4036259 | 8.4034927 | 8.4046770 | 8.4002263 | 8.4055117 | 8.4053779 | 8.4065569 | 8.4021258 | 8.4036259 | 8.4034927 | 8.4046770 | 8.4002263 | 8.4055117 | 8.4053779 | 8.4065569 |
| +log N N' | 0.2087100 | 0.2087100 | 0.2074135 | 0.2119317 | 0.2087100 | 0.2087100 | 0.2074135 | 0.2119317 | 0.2087100 | 0.2087100 | 0.2074135 | 0.2119317 | 0.2087100 | 0.2087100 | 0.2074135 |
| log sin I' | 8.6123359 | 8.6122027 | 8.6120905 | 8.6121580 | 8.6142217 | 8.6140879 | 8.6139704 | 8.6140575 | 8.6123359 | 8.6122027 | 8.6120905 | 8.6121580 | 8.6142217 | 8.6140879 | 8.6139704 |
| +log r | 2.5682017 | 2.5682017 | 2.5682017 | 2.5682017 | 2.5622929 | 2.5622929 | 2.5622929 | 2.5622929 | 2.5682017 | 2.5682017 | 2.5682017 | 2.5682017 | 2.5622929 | 2.5622929 | 2.5622929 |
| log r sin I' | 1.1805376 | 1.1804044 | 1.1802922 | 1.1803597 | 1.1765146 | 1.1763808 | 1.1762633 | 1.1763504 | 1.1805376 | 1.1804044 | 1.1802922 | 1.1803597 | 1.1765146 | 1.1763808 | 1.1762633 |
| -log sin U' | 8.5174301 | 8.5172355 | 8.5171167 | 8.5171827 | 8.5182604 | 8.5181321 | 8.5180004 | 8.5180926 | 8.5174301 | 8.5172355 | 8.5171167 | 8.5171827 | 8.5182604 | 8.5181321 | 8.5180004 |
| log (L'-r) | 2.6631075 | 2.6631689 | 2.6631755 | 2.6631770 | 2.6582542 | 2.6582487 | 2.6582629 | 2.6582575 | 2.6631075 | 2.6631689 | 2.6631755 | 2.6631770 | 2.6582542 | 2.6582487 | 2.6582629 |
| U | 0.59-25 | .017280 | .017350 | .017090 | 0.59-25 | .017280 | .017350 | .017090 | 0.59-25 | .017280 | .017350 | .017090 | 0.59-25 | .017280 | .017350 |
| +I | -1.27-05 | -.025322 | -.025391 | -.025132 | -1.27-28 | -.025432 | -.025501 | -.025242 | -1.27-05 | -.025322 | -.025391 | -.025132 | -1.27-28 | -.025432 | -.025501 |
| U+I | -0.27-40 | -.008042 | -.008041 | -.008042 | -0.28-03 | -.008152 | -.008151 | -.008152 | -0.27-40 | -.008042 | -.008041 | -.008042 | -0.28-03 | -.008152 | -.008151 |
| -I' | 2.20-51 | .040945 | .040935 | .040941 | 2.21-27 | .041123 | .041112 | .041120 | 2.20-51 | .040945 | .040935 | .040941 | 2.21-27 | .041123 | .041112 |
| U' | 1.53-11 | .032903 | .032894 | .032899 | 1.53-24 | .032971 | .032961 | .032968 | 1.53-11 | .032903 | .032894 | .032899 | 1.53-24 | .032971 | .032961 |
| L'-r | 460.371 | 460.436 | 460.443 | 460.444 | 455.254 | 455.249 | 455.264 | 455.258 | 460.371 | 460.436 | 460.443 | 460.444 | 455.254 | 455.249 | 455.264 |
| r | -370.000 | -370.000 | -370.000 | -370.000 | -365.000 | -365.000 | -365.000 | -365.000 | -370.000 | -370.000 | -370.000 | -370.000 | -365.000 | -365.000 | -365.000 |
| L' | 90.371 | 90.436 | 90.443 | 90.444 | 90.254 | 90.249 | 90.264 | 90.258 | 90.371 | 90.436 | 90.443 | 90.444 | 90.254 | 90.249 | 90.264 |

U. S. CIVIL SERVICE POSITIONS

Men and women with training in chemistry, geology, geophysics, mathematics, metallurgy, meteorology, physics, and radio, are needed by the Civil Service Commission to fill positions as technical and scientific aids. Applicants may qualify through experience or education. The majority of positions are in Washington, but some will be filled in other parts of the United States. There are no age limits, and no written test is required. The positions pay \$1,620 to \$2,600, plus overtime.

Trainee positions in technical and scientific work will also be filled in Washington and vicinity. The salary is \$1,440 a year plus overtime, and the only educational requirement is that the applicant must have completed one high school credit of physics, chemistry, mathematics, biology, or general science.

Applications and complete information may be obtained from first- and second-class post offices, or from the U. S. Civil Service Commission, Washington, D. C.

Persons using their highest skills in war work are not encouraged to apply for these positions.

SKY-GAZERS EXCHANGE

Classified advertisements accepted for this column at 30c a line per insertion, 7 words to the line. Minimum ad 3 lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard College Observatory, Cambridge, Mass.

WANTED: Perfect achromatic objective lens, 3 3/4, 4, or 5 inches; reasonably priced. Hurry. Write to Tom Keene, Box 431, San Antonio, Tex.

WANTED: A good solar prism; also McLean type spectroscopic eyepiece. Both 1 1/4" size. P. O. Parker, Box 193, Ooltewah, Tenn.

WANTED: A 360- or 359-tooth worm gear with worm to match. Gear diameter between 6" and 12". Any bore diameter. Stanley Brower, 27 Wenzel Terrace, Stamford, Conn.

FOR TRADE: A 1/4" Ramsden eyepiece for a 1/3" of any make. Standard 1 1/4" tubing. Raymond Schmidt, Box 841, Silver City, N. Mex.

WANTED: A 3" or 3 1/2" refractor telescope, Clark, Brashear, Mosey, or equal, on simple equatorial tripod mount. Harry Roegge, 2357 Clifton Ave., Cincinnati, Ohio.

BINOCULARS REPAIRED: Prism binoculars—field glasses—spotting scopes—telescopic sights—microscopes—resilvering of prisms and mirrors. We repair, overhaul, make replacements, and accurately collimate all foreign and domestic makes of prism binoculars, field glasses, and microscopes.

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J. W. FECKER

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By I. BERNARD COHEN

Here's the latest publication of the Burndy Library—the book reviewed by Edward Rosen as one “which will be widely welcomed . . . a lively and interesting study of one of the most important discoveries underlying the history of science.”

This 63-page book is priced at only 50c. For the Burndy Library is a non-profit organization devoted to the publication of works of great historical significance. Write for a copy now, or ask to have your name placed on the Library mailing list.

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BOOKS AND THE SKY

NICHOLAS COPERNICUS 1543-1943

STEPHEN P. MIZWA. The Kosciuszko Foundation, New York, 1943. 88 pages. 75 cents.

SELDOM would it seem proper to begin the review of a book with a discussion of its cover. Yet in this instance the cover is so strikingly beautiful, and holds one's attention so long, that we feel justified in starting our review at the very beginning of Stephen Mizwa's brochure. The cover design, contributed by a Polish refugee, Arthur Szyk, is a symbolic portrait in color done in the style of medieval illuminated manuscripts.

Written on the occasion of the quadricentennial of the death of Nicholas Copernicus, the pamphlet is a brief but compensatingly authentic account of the life, antecedents, and country of Copernicus.

All the world knows about the achievement of Copernicus the astronomer: “The sun he bade to stop, and at his bidding the earth began to spin.” His clear conception of the motions within the solar system so outshines his other works that Dr. Mizwa does a real service in calling to our attention the wide versatility of the man, who was also an economist, a churchman, statesman, physician, and soldier. In all of these capacities he was a recognized leader.

Copernicus had been brought up for the church, and from about 1505 on, he pursued active duties as canon of the duchy-bishopric of Varmia. The facts that Copernicus was

born in Torun and spent most of his active life in Varmia, localities both of which later became part of the German Empire, have led to speculations in the past that Copernicus might have been a German rather than a Pole. These speculations were enhanced by uncertainties as to the exact spelling of his name, at least 10 variants of which are extant. Some of these, the adherents of the German theory claimed, could not have been Polish. This theory is vehemently disproved in Mizwa's discussion. It leaves no question about Copernicus' Polish origin or Polish allegiance. Indeed, during the war with the Knights of the Teutonic Order, begun in 1520, churchman Copernicus was the commander-in-chief of the beleaguered Polish city of Olsztyn (Allenstein).

During his lifetime, Copernicus fared more peacefully in his science than did Galileo later in his support of the Copernican theory. “Audacious as a thinker and not lacking even in physical courage,” writes Mizwa, “Copernicus was timid in pushing his own discoveries. He wanted to check and recheck all details before eventual publication.” This commendable trait unfortunately postponed the publication of *De Revolutionibus* so many years that the author himself barely lived to see the first printed copy on his deathbed, when he was 70 years old. Then he did not notice that his own foreword had been replaced by another. The proofreader, Andreas Osiander, fearing the possible objection to so revolutionary a treatise, had cleverly and spuriously directed the foreword to “the reader of the hypothesis of this work.” That “hypothesis” succeeded in keeping *De Revolutionibus* from the church's fatal Index for more than 70 years.

Part III of the brochure, “Program Suggestions,” is a very useful chapter for schools or clubs wishing to celebrate the Copernican quadricentennial. Illustrations of student costumes in Copernicus' time, suggestions for music, and lecture topics are given.

The amount of detail, the scholarliness combined with an easy style, the sincerity of national feeling, and the 20 fine illustrations, all contained within so few as 88 pages, are a credit to the author. The pamphlet should prove to have a lasting value, not merely temporal interest as an anniversary souvenir.

DORRIT HOFFLEIT
Harvard College Observatory

An important new book by the author of “The Mysterious Universe,” “The Universe Around Us.”

PHYSICS and PHILOSOPHY

By Sir James Jeans

In this book Sir James Jeans asks questions that touch ourselves and our lives very closely, such as: “Can we have any knowledge of the world outside us, other than we gain by the methods of science—observation and experiment?” “Is the world ultimately spiritual and mental, or material in its ultimate essence?” “Are we humans endowed with free will, or are we mere cogs in a vast machine, which must follow its destined course until it finally runs down?”

This book starts simply, with a definition of physics and of philosophy. The author then gives a clear account of the progress of philosophical thought from the time of the Greeks, through the Middle Ages, the Renaissance, Hegel, Spinoza, Descartes, and Kant, down to Sir Arthur Eddington, with whom Sir James Jeans finds several points of disagreement. He then traces the progress of physics since the time of Newton, and also shows how the modern theories of physics affect our ways of thought on religion, on free will, and on the nature of man.

“Physics and Philosophy” is written with the lively sparkle that marks all that Sir James writes. It is this quality that enables him to make abstruse arguments intelligible to lay readers.

Probable price, \$2.75

THE MACMILLAN COMPANY

60 Fifth Avenue, New York

Boston

Chicago

San Francisco

Dallas

Atlanta

A MATHEMATICS REFRESHER

A. HOOPER. Henry Holt and Co., New York, 1942. 342 pages. \$2.50.

THIS is a revised edition of *A Mathematical Refresher*, originally written for the Royal Air Force candidates who found their mathematics rusty through disuse, or who, when brought face to face with facts, had to admit that they had not properly grasped the subject at school. But, as the author points out in the preface, mathematical weakness crops up in the New World as well as in the Old, so this book should also be of great help to air crew candidates in Canada and the United States.

But the book can be used by all those

who claim they "can't do mathematics," or those who through bad teaching had an intense dislike for the subject. After careful study, they will find out how simple it really is and will have to admit that they too can "do" mathematics. As Thompson has pointed out in his excellent volume, *Calculus Made Easy*, "What one fool can do, another can."

Oranges, although used mainly for the vitamins they contain, may enable one to grasp the abstract ideas of latitude and longitude, and the author's use of them for this purpose is excellent.

The contents take one from arithmetic to trigonometry and logarithms. Decimal fractions are no longer "dismal fractions," as they used to be at school. Arithmetic, algebra, geometry, trigonometry, and mechanics are not treated as different subjects, but dovetail naturally into one another.

The chapter on logarithms might be improved with a short table of logs, besides the sample page given. The chapter on simultaneous equations might also have a solution by determinants, which are easy to understand, and would give the student a brief review of that interesting subject.

The diagrams are clear and concise, and the short explanations of velocity, acceleration, gravity, and the parallelogram law, usually missing from American textbooks on elementary mathematics, certainly add to the value of the book.

A number of the problems at the end of the book should be worked out. For one learns only by doing.

The book makes an excellent review for those who wish to refresh their memories, and also for those who desire to find out something of the beautiful simplicity of mathematics.

MAX TRUPIN
New York A.A.A.

SCIENCE REMAKES OUR WORLD

JAMES STOKLEY. Ives, Washburn, New York, 1942. 299 pages. \$3.50.

WHEN at the turn of the year the New York *Herald-Tribune* invited James Stokley to undertake a new department for technical books in its Sunday "Books" section, it was doubly good news. Technical books received recognition that was long overdue. And James Stokley emerged as a broad, scholarly, authoritative spokesman for science, as welcome to the public eye as he had long been to astronomers. As director, first of the Fels Planetarium, then of Buhl, he had a large following who missed him in his comparative anonymity when he took charge of press relations for the Research Laboratory of the General Electric Company at Schenectady. Now this superb book presents him in full stature.

Science Remakes Our World is not merely a popular book in science, not even in applied science. It is a lavish description of modern living and its background in materials and energy. More than that, it is an intimate account of recent events in the laboratories of chemistry and physics, the "birthplace of the future," and what they mean for the pattern of American life in the years that lie ahead. Always the author remembers what America has yet to learn:

that science is above all else a tremendously powerful social force.

Many of the topics are familiar in newspaper headlines—synthetic rubber, 100-octane aviation fuel, aluminum, vitamins. But here is the authoritative background that newsreaders lack: the history, the meaning of the technical terms, the scientific concepts and research ideas, the personalities and laboratories involved. Other topics are war devices, like the plane-detector, which have been fogged by secrecy and censorship but are here described in all permissible simplicity and clarity. Still others—television, short-wave radio, new lighting devices and power sources—are infants of the future. The index lists a thousand items and reveals that this is really an encyclopedia of today's science, though

NEW BOOKS RECEIVED

WORKBOOK IN METEOROLOGY, *Spilhaus and Miller*. 1942, McGraw-Hill. 163 pp. \$2.50. Accompanying maps and charts—50c.

Just what its name implies, this book is designed to formalize and systematize practical problem work in courses in elementary meteorology of college grade. Exercises, to be worked in conjunction with recommended texts, are arranged into four groups: Mean Condition of the Atmosphere; Instruments and Methods of Observation; Exercises in Dynamical Meteorology; Weather-Map and Upper Air Analysis. Additional sets of the 27 excellent supplementary maps and charts may be obtained from the publisher.

MANUAL FOR OBSERVATIONAL AND PRACTICAL LABORATORY WORK IN ELEMENTARY ASTRONOMY, *Oscar Lee Dustheimer*. 1942, Edwards Bros., Inc., Ann Arbor, Mich. 100 pp. \$1.25; \$1.00 to professors and libraries.

A new edition of a manual designed to supplement formal textbook instruction with practical laboratory exercises. A number of the problems are of value for pre-training astronomy courses.

Sauce for the Gander

READERS are asked to send in questions, from which this editor will select the best each month to answer here. The last question is left unanswered, but the reader should be able to find the answer for himself. This month's questions came from Raymond E. Taylor, of Newark, N. J., and Miss Caryl Annear, of Ocean Grove, N. J.

Q. Why is the dark portion of the crescent moon visible by earthshine, but not the dark portions of the new moon, the quarter moons, and the moon during an eclipse of the sun?

A. The light which the moon receives from the earth is at best (when the earth is "full" as seen from the moon) only about eight parts in 100,000 of what the moon receives from the sun. Consequently, the earthshine on the moon is visible only under the most favorable circumstances: when the

it reads like a raconteur's calm story of great adventures.

There have been many past attempts to portray the world of industrial research and its implications for society. They suffer from being childish in their transparent propaganda, or superior in approach. Stokley writes maturely for mature minds. His essays are informative, in good taste, and make sense.

I would nominate him to give us an annual review of what is happening to us at the hands of science. It would be required reading for every banker, industrialist, politician, newspaperman, and, above all, for every educator. And I'd start them all out with *Science Remakes Our World*.

GERALD WENDT
Time and Life Building, N. Y.

THE GREATEST EYE IN THE WORLD, *A. Frederick Collins*. 1942, Appleton-Century. 266 pp. \$3.00.

A popular account of the history of telescopes, and of nine large observatories.

ODD NUMBERS, *Herbert McKay*. 1943, Macmillan. 215 pp. \$2.00.

The first American edition of a popular book on the varied uses of numbers. Its readers need to be familiar with only the ordinary processes of arithmetic.

BASIC PRINCIPLES OF WEATHER FORECASTING, *Victor P. Starr*. 1942, Harper. 299 pp. \$3.00.

As the title shows, this is a book devoted to weather forecasting and its problems, rather than to a general discussion of meteorology, with which the reader is presumed to be familiar.

PHYSICS AND PHILOSOPHY, *Sir James Jeans*. 1943, Macmillan. 222 pp. \$2.75.

This book by Sir James Jeans should be widely read because it clearly presents the physical implications of the historical philosophies and the philosophical implications of modern physics. It has, moreover, many examples of the author's skill with word pictures and with clarifying analogies.

earth is near "full" and when the contrast with the sunlit portion of the moon is not too strong. This holds near the times of new moon, when the moon is a crescent. But when the moon is just new, it is between the earth and the sun (or nearly so) and visible only against a background of illuminated sky. During an eclipse of the sun, the background of light—even of the corona—is still too bright for the earthlight on the moon to be seen.

Q. At what rate and in what apparent direction is the galaxy moving?

A. This is unknown. Furthermore, there is little hope of our discovering the answer until the nature of the red shift observed in the spectra of the exterior galaxies is finally determined.

Q. What are the geographical latitudes and longitudes of the north and south magnetic poles?

L. J. LAFLEUR



DEEP-SKY WONDERS

THIS month finds the following objects in good position for observation with moderate-sized telescopes. Descriptions are from Norton's *Star Atlas*.

Canes Venatici. M63, $13^h 13.6^m$, $+42^\circ 18'$; a bright, oval nebula, $8'$ by $3'$, with a central nucleus, and an 8th-magnitude star closely preceding. M51, $13^h 27.8^m$, $47^\circ 27'$; the larger of two nebulae nearly in contact; shows spiral in a 12-inch telescope. It is the famous Whirlpool nebula, and is pic-

tured, together with its more nebulous companion, on the back cover this month. M3, $13^h 39.9^m$, $+28^\circ 38'$; a bright, condensed globular, whose outer parts can be resolved in a 4-inch telescope, and the whole cluster in a 6-inch with high power.

Hydra. N.G.C. 3242, $10^h 22.3^m$, $-18^\circ 23'$; a planetary nebula $40''$ by $35''$, with a brighter inner ring and pale blue tint.

Monoceros. N.G.C. 2244, $6^h 30.0^m$, $+4^\circ 54'$; a beautiful open cluster of 7th- to 14th-magnitude stars, visible to the naked eye.

THE STARS FOR APRIL

as seen from latitudes 30° to 50° north, at 10 p.m. and 9 p.m. on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

AIR AND SEA AND STARS

A department devoted to wartime subjects related to astronomy, such as aerial and celestial navigation, and meteorology.

NAVIGATING IN THE AIR — I

DURING World War I, aircraft were of short range, and operated over limited territory. There were no planes capable of sustained flight. From the lessons learned in that war, bigger and better aircraft were built during the 1920's. In the 1930's still bigger ships were built—craft capable of sustained flight over great expanses of land and sea.

With the advent of these aircraft, the navigator took his place as an essential member of the crews of certain planes. Airplanes operated within the limits of the continental United States did not require a navigator—still do not. Radio range stations strategically placed over the country, lighting systems, all made navigation unnecessary, as they were intended to do. Only the huge trans-oceanic planes required the services of a precision navigator.

When better commercial craft were built, so were better Army planes constructed. These planes were not intended to fly the commercial airways, and could not depend upon the many and various Federal aids to navigation. In combat, it is essential that the plane be entirely independent, able to fly anywhere, over the shortest routes, regardless of ground installations—which usually do not even exist in combat zones.

So it became necessary for the Army to train navigators. It may seem strange, at first thought, that there are thousands of navigators in the Army—probably as many as in the Navy. A navigator in khaki is a new concept. Nevertheless, navigating is a very important part of Army training, particularly for the men who fly.

Although in theory there is no difference between navigating a ship and navigating an airplane, these two jobs are very different in practice. Airplanes traverse a three-dimensional element, traveling as far in an hour or so as surface craft move in a whole day. Therefore, an entirely new technique of air navigation had to be evolved, although it meant the coining of new terms and of new methods of doing the older things.

Navigation is generally defined as the science of determining the position of a craft at any instant. Basically, however, it is the purpose of navigation to conduct a vessel from one point to another, and all other factors are subordinate to that. It is especially important to remember this in the air, where course changes are numerous and frequent in order to keep the craft on course. This is the foundation of the admonition to student navigators in the Air Corps that a good log has at least one entry in it every five minutes. During those five minutes, the plane has traveled anywhere from 10 to 25 miles, unless it is especially fast. To fly off course for that distance might result in the failure of the mission, or mean the difference between life and death.

Thus, the essence of air navigation is speed. The navigator, who must be quick and accurate, has at his command everything which will aid him to perform his

task as rapidly as possible. And, World War II introduced a new element. In addition to making things easier to do, it was necessary to make things easier to learn. Having already stripped the older navigation of all non-essentials, there was only one way left to do this. It was probably not planned in that manner, but the result was that mariners' methods were jettisoned entirely, and a new kind of navigation invented—perhaps without anyone realizing it was being done.

The result is a streamlined navigation as different from the orthodox methods as it is possible to be. In theory and practice, the two techniques—sea and air—are very similar: it is in pedagogy that they differ. The mariner and the aeronaut speak two different languages when they are talking about the same thing. This is possibly of but academic interest, and will probably be ironed out in time. Meanwhile, it is something to bear in mind in any study of air navigation.

Of interest particularly to readers of *Sky and Telescope* is the stress laid on celestial methods in the Air Corps. The reason for this is that celestial navigation is the only means of certainly fixing the position of the craft anywhere in the world. Pilotage (comparing the ground with a map) is impossible over water, of course, and over large stretches of ground in Asia which have never been well mapped. Radio navigation, as mentioned above, is completely out of the question. Dead reckoning is not to be relied upon over long intervals of time—say a couple of hours. Only celestial navigation is independent of maps, ground facilities, and cumulative errors. Therefore, great emphasis is placed on learning to navigate by the stars.

The fundamental method of using a line of position obtained from a sight of a celestial body is not very old. As described in one of a recent series of articles in this magazine, the existence of such a line was discovered by Capt. Thomas Sumner, a Yankee skipper, in 1838. He began what was subsequently called the "new naviga-

tion," based on very simple principles, which we shall briefly express here for future reference.

The basic axiom is that the zenith distance of a celestial body, for any observer, is equal to his distance from that point on the earth where the body is overhead. An observation of a single star or planet, or of the sun or moon, then, will tell the navigator that he is somewhere on the circumference of a circle whose center is that point where the body is overhead, and whose radius is equal to the zenith distance of the body.

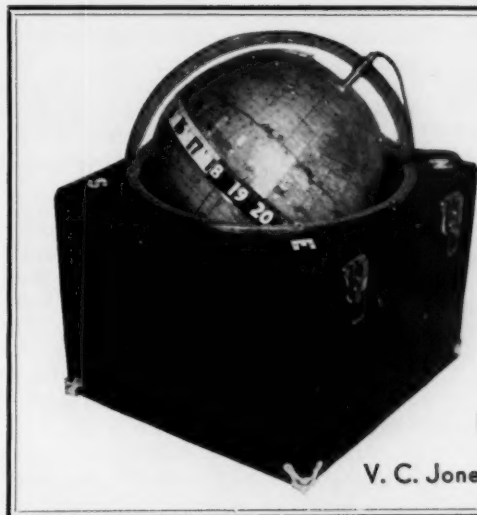
A second body can now be observed, giving a second circle of position. The two circles intersect each other at two points, usually thousands of miles apart. The observer is at one of these intersections, and he is never in doubt as to which one.

A great stride forward was developed by Admiral Marcq St.-Hilaire, of the French Navy, in the latter part of the 19th century. Essentially, his method is first to compute the zenith distances of the bodies to be observed. Then if the observation of one of them shows the actual zenith distance to be greater, the observer is farther from the body than he anticipated, and vice versa.

As commonly practiced, the entire circle of position need not be drawn upon the chart. Only a small segment of it, for practical purposes a straight line, is charted, and it is the line of position, or Sumner line. The intersection of two such lines, obtained from simultaneous observations, is the position of the observer: the fix.

The line of position has many applications. For example, when only the sun is visible in the daytime, it is impossible to obtain more than one such line at any time, and therefore no fix can be obtained from celestial sights alone. Nevertheless, the knowledge that the observer is located along that one line of position may be very helpful, just as it was in the classic case of Capt. Sumner himself, when he discovered the method. He was unable to get a fix, but he found that the line of position he was on passed through a certain lighthouse. He followed the line (as he had plotted it on his chart), knowing that sooner or later he would pick up the light.

Because of the many applications of this method, it is now preferred among the navies of the world, and in our Air Corps, as well. In our next installment, we shall discuss the theory of the line of position in detail. S.S.



Model Planetarium

CELESTIAL and terrestrial objects maintained in proper orientation automatically. The sky is shown as it actually is viewed from any part of the world. The device may be used without the case as a world time globe.

U. S. Patent for Sale.

V. C. Jones, 109 Lanark St., Winnipeg, Canada

OBSERVER'S PAGE

By JESSE A. FITZPATRICK

All times mentioned on the Observer's Page are Eastern war time.

WHIPPLE'S COMET

THE following ephemeris has been furnished by the comet's discoverer, Dr. Fred L. Whipple, of Harvard College Observatory:

April 2, 12^h 43^m, +46° 30'; April 10, 12^h 46^m, +43° 16'; April 18, 12^h 48^m, +39° 49'; April 26, 12^h 52^m, +36° 17'.

May 4, 12^h 55^m, +32° 45'; May 12, 12^h 59^m, +29° 16'; May 20, 13^h 04^m, +25° 55'; May 28, 13^h 10^m, +22° 43'.

June 5, 13^h 16^m, +19° 41'; June 13, 13^h 23^m, +16° 50'; June 21, 13^h 30^m, +14° 10'; June 29, 13^h 37^m, +11° 39'.

The naked-eye brilliancy of Comet Whipple has been a pleasant surprise. Some observers reported the comet to have equalled the brightness of δ Ursae Majoris (Megrez), which has a photometric magnitude of 3.44. Photographs on February 26th showed a tail 15 degrees long.

The discrepancy of about two magnitudes between observations and predictions is not unusual among comets. Vagaries of comet brightnesses are so marked that many orbit computers do not attempt to predict magnitudes at all. Most noteworthy in this respect is periodic Comet Schwassmann-Wachmann, which occasionally increases in brightness in a few days by 100 times, five magnitudes, without any apparent cause.

Thus, magnitude predictions for comets serve only as a general indication of expected changes in brightness. It is impossible to predict when Comet Whipple may begin to fade rapidly beyond the limit of naked-eye brightness, but probably some time in April it will be only a telescopic object. Based on a magnitude of 4.0 at perihelion, the comet's brightness is estimated by Dr. Whipple to be 6.1 on April 10th; 7.6 on May 12th; and 9.0 on June 13th.

AURORAE SEEN

Reports have been received from amateurs in the northeastern United States of displays of the aurora borealis on the evenings of February 25th and March 3rd. Recent Mt. Wilson observations indicate that the new sunspot cycle may be starting, so aurorae may become more frequent.

Dr. Seth B. Nicholson recently reported that on December 20th a sunspot group appeared in the relatively high solar latitude of 32 degrees, and may have begun the new solar cycle.

THE REAL CAPELLA H.

Dr. Peter van de Kamp, director of Sproul Observatory, has written to the following effect:

The 10th-magnitude companion of Capella, referred to in *Sky and Telescope*, February, 1943, as Capella H, is Capella F (also H VI 30 = h 2256). As far as I know, the star is not double.

Capella H (Furuhjelm's companion) is at a distance of 723'' from Capella. It has a close companion at a distance of 1''.8, discovered by Stearns (*Astronomical Journal*, 45, 120, 1936). The binary Capella H shares the proper motions of Capella and is there-

fore a genuine, physical companion. All the other companions are optical—their separations and position angles change continually.

PHASES OF THE MOON

New moon April 4, 5:53 p.m.
First quarter April 12, 11:04 a.m.
Full moon April 20, 7:11 a.m.
Last quarter April 27, 3:51 a.m.

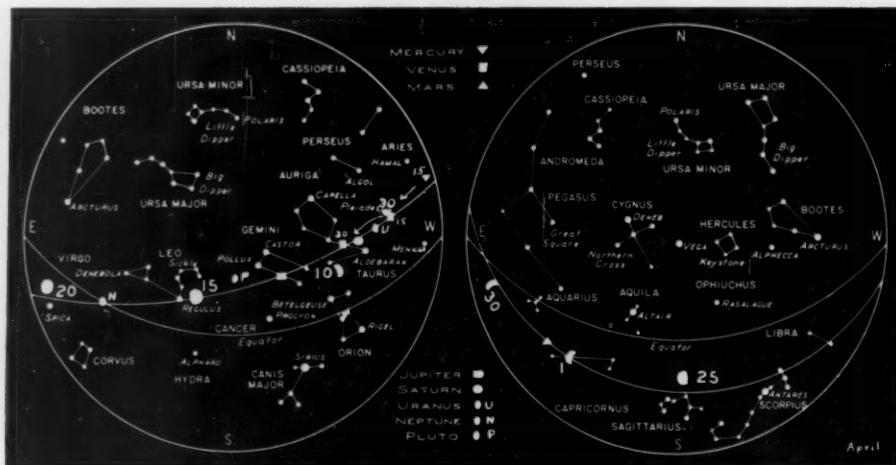
OCCULTATIONS—APRIL, 1943

| Local station, lat. 40° 48'.6, long. 4 ^h 55.8 ^m west. | | | | | | |
|---|------|------------------|--------------|-------|--------------|------|
| Date | Mag. | Name | Immersion | P.* | Emersion | P.* |
| Apr. 7 | 6.9 | BD +13° 579 | 8:18.1 p.m. | 77° | | |
| 8 | 6.5 | 275 B Tauri | 9:58.4 p.m. | 139° | 10:34.0 p.m. | 212° |
| 8 | 1.1 | Aldebaran | 10:52.3 p.m. | 97°** | | |
| 10 | 5.2 | 71 Orionis | 9:01.3 p.m. | 66° | 10:08.2 p.m. | 303° |
| 14 | 7.2 | 52 Cancr | 0:30.7 a.m. | 59° | | |
| 15 | 6.9 | BD +13° 2131 | 0:01.6 a.m. | 104° | | |
| 15 | 6.8 | 47 B Leonis | 0:59.7 a.m. | 131° | | |
| 15 | 6.8 | BD +11° 2217 | 9:23.4 p.m. | 79° | | |
| 16 | 3.8 | α Leonis | 3:30.3 a.m. | 158° | 4:08.8 a.m. | 242° |
| 22 | 4.0 | γ Librae | 1:02.8 a.m. | 92° | 2:18.2 a.m. | 311° |
| 27 | 5.3 | ν Capricorni | 4:17.0 a.m. | 139° | 4:57.9 a.m. | 205° |

* P is the position angle of the point of contact on the moon's disk measured eastward from the north point.
** Emersion is below the horizon.

On April 9th, the star 115 Tauri, magnitude 5.3, will be in conjunction with the moon at 11:24.8 p.m. at our local station. This conjunction is unusual since the computations show the star to be exactly on the moon's southern edge at that moment. Of course, there will be a slight occultation due to the star passing behind the mountains which are numerous near the south pole and project beyond the moon's theoretical limb. The position angle of the moon's axis, 357°, will bring the conjunction very near the actual south pole, which in the five-day-old moon will be marked by the tip of the southern horn. In latitudes one degree or more north of our local station there will be a decided occultation.

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 6:30 a.m. on the 7th of the month, and at 5:30 a.m. on the 23rd. At the left is the sky for 8:30 p.m. on the 7th and for 7:30 p.m. on the 23rd. The moon's position is marked for each five days by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury will be at greatest elongation east, 20° 45', on April 30th. Its path, 8° north of the path of the sun, will make this the most favorable elongation of the year for observers in northern latitudes. The planet should be seen in the evening sky for several days before and after this date. It will be near Saturn, Aldebaran, and the Pleiades.

Venus, in Aries and Taurus, will be in conjunction with and north of the planet Uranus by 1° 27' on April 17th.

Mars, in Capricornus and Aquarius, is getting closer to the earth and its magnitude will be 1.0 at the end of the month, but it is still too distant to have special observational interest.

Jupiter, in Gemini, will be in close conjunction with the double star, δ Geminorum, on April 21st. The planet will be 35' north of the star.

Saturn is in Taurus.

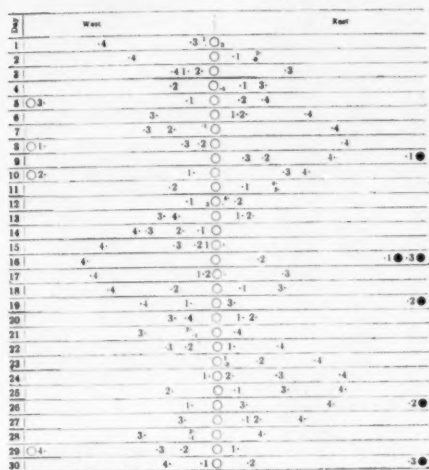
Uranus. See chart in the January issue.

Neptune. See chart in the March issue.

JUPITER'S SATELLITES

On April 8th, after 11:51 p.m., the four principal moons will be east of the primary. On the 13th, they will be west of the primary and in numerical order, with I nearest the planet.

Jupiter's four bright moons have the positions shown below at 11:45 p.m., E. W. T., on the day preceding the date shown. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the American Ephemeris.



CONJUNCTIONS

On April 8th, the star 264 B Tauri, magnitude 4.8, will be in conjunction with the moon at 8:45.3 p.m. It will be south of the moon's edge by a distance equal to 4.4 per cent of the moon's diameter.

On the 16th, the star 45 Leonis, of magnitude 5.9, will be in conjunction with the moon at 0:40 a.m. It will be south of the edge of the moon by a distance equal to five per cent of the moon's diameter.

In both these cases, the stars will be occulted in latitudes slightly north of our local station.

LIST OF DOUBLE STARS—R. A. 8h to 12h

THIS is the last in a series of lists of double stars visible from the Northern Hemisphere. Previous lists have appeared in Sky and Telescope for alternate months beginning with June, 1942. Copies of these issues are still available.

| Star | R. A. h m | Dec. ° ' | Photometric mag. A+B A B | Aitken mag. | Spectra A B | Sep. " | P.A. ° |
|------------|----------------------|----------------|-----------------------------|----------------|----------------|-----------|-----------|
| Cancer | ζ ² | 8 09.4 +17 48 | 5.10 5.56 6.26 | 5.0—5.7 | G0 | 0.6 | (30) |
| | | 8 09.4 +17 48 | 6.02 | 5.0—5.5 | G0 | 5.4 | (100) |
| | φ ² | 8 23.8 +27 06 | (5.6) 6.30 6.32 | 6.0—6.5 | A2 | 6.0 | 219 |
| | ι | 8 43.7 +28 57 | 4.20 | 4.4—6.5 | G5 | 30.8 | 307 |
| | 57 | 8 51.2 +30 46 | 5.60 | 5.9—6.4 | K0 | 1.5 | 323 |
| Hydra | α | 8 55.8 +12 04 | 4.27 | 4.5—11.0 | A3 | (11.0) | (324) |
| | ε | 8 44.1 + 6 36 | 3.48 | 3.8—7.8 | F8 | 3.2 | 250 |
| | 17 | 8 53.0 — 7 47 | (6.0) 6.67 6.91 | 7.2—7.3 | A3 | 4.3 | 359 |
| | θ | 9 11.8 + 2 32 | 3.84 | 4.0—10.0 | A0 | (30.0) | 190 |
| | N | 11 29.8 —28 59 | (5.1) 5.78 5.86 | 6.0—6.0 | G0 | 9.0 | 210 |
| Leo | β | 11 50.4 —33 38 | 4.40 | 5.1—5.5 | B9 | (1.8) | (360) |
| | γ | 10 17.2 +20 06 | (2.3) 2.61 3.80 | 2.0—3.5 | K0 | 3.9 | 120 |
| | 54 | 10 52.9 +25 01 | 4.51 | 5.0—7.0 | A0 | 6.2 | 109 |
| | ι | 11 21.3 +10 48 | 4.03 | 3.9—7.1 | F5 | (1.5) | (20) |
| | 90 | 11 32.1 +17 04 | 5.76 6.05 (7.3) | 6.0—7.3 | B3 | 3.3 | 209 |
| Lynx | Σ1333 | 9 15.4 +35 35 | 5.76 | 6.6—6.9 | A5 | 1.7 | 47 |
| | 38 | 9 15.7 +37 01 | 3.82 | 4.0—6.7 | A2 | 2.8 | 233 |
| Monoceros | Σ1183 | 8 04.0 — 4 06 | 5.92 | 5.5—7.8 | A0 | 30.9 | 325 |
| Sextans | 35 | 10 40.8 + 5 01 | 6.34 | 6.1—7.2 | K0 | (6.5) | (235) |
| Ursa Major | ι | 8 55.8 +48 14 | 3.12 | 3.1— | A5 | (6.0) | (3) |
| | (σ ²) 13 | 9 06.0 +67 20 | 4.87 | 5.0—8.2 | F8 | (1.5) | (50) |
| | 23 | 9 27.6 +63 17 | 3.75 | 3.8—9.0 | F0 | 22.8 | 271 |
| | ξ | 11 15.6 +31 49 | (3.9) 4.41 4.87 | 4.0—4.9 | G0 | (2.0) | (70) |
| | ν | 11 15.8 +33 22 | 3.71 | 3.7—10.1 | K0 | 7.2 | 148 |
| | 57 | 11 26.4 +39 37 | 5.26 | 5.2—8.2 | A2 | 5.5 | 2 |
| | 65 | 11 52.5 +46 45 | 6.46 | 7.2—8.3 | A0 | 3.7 | (40) |

* The first line gives information for the close A-B pair, the second, for the A-C pair.

The columns are: star designation; right ascension, declination (1950); photometric magnitudes; "Aitken" visual magnitudes; spectral classes; separation; position angle.

A and B are the brighter (primary) star and fainter star, respectively. Where available, the photometric magnitudes are given to two places; magnitudes in parentheses are estimated or uncertain. "Aitken" magnitudes

are from visual observations and often differ greatly from the photometric figures, therefore the former are useful chiefly to indicate the relative magnitude difference between the components.

The data for this table is compiled from the *Boss General Catalogue*; *Aitken's Double Star Catalogue*; and *Innes' Southern Double Stars*.

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ THE BUHL PLANETARIUM presents in April, THE EASTER STORY.

Have you ever wondered why Easter falls on different dates in different years? Why some years it comes early and some years late? The reason is an astronomical one, for the rule for determining the Easter date—a rule which has come down to us from very early times—involves the phases of the moon as well as the vernal equinox. History tells us that the moment of the vernal equinox, when the sun crosses the equator to usher in spring officially, was celebrated thousands of years ago by many ancient peoples. The Easter celebration, symbolizing the rebirth of life in spring, also comes about the time of the equinox. Yet it does wander about the calendar rather surprisingly, and that is where a certain full moon enters the picture—and the Planetarium sky.

★ THE HAYDEN PLANETARIUM presents in April, WEATHER SIGNS IN THE SKY. (See page 14.)

In May, we join in celebrating the 400th anniversary of the death of the founder of modern astronomy, Nicholas Copernicus. Facts about his system of astronomy, and a naturalistic portrayal of the retrograde motions of the planets which his system and none other can explain, are presented in the planetarium sky. The demonstration with the never motionless "Copernican planetarium," held on the first floor before the main show upstairs, takes on added significance in May.

★ SCHEDULE BUHL PLANETARIUM

Mondays through Saturdays (except Tuesdays).....3 and 8:30 p.m.
Sundays and Holidays.....3, 4, and 8:30 p.m.
(Building closed Tuesdays)

★ STAFF—Director, Arthur L. Draper; Lecturer, Nicholas E. Wagon; Manager, Frank S. McGary; Public Relations, John J. Grove; Chief Instructor of Navigation, Fitz-Hugh Marshall, Jr.; Instructor, School of Navigation, Edwin Ebbighausen.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays.....2, 3:30, and 8:30 p.m.
Saturdays11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays.....2, 3, 4, 5, and 8:30 p.m.

★ STAFF—Honorary Curator, Clyde Fisher; Curator, William H. Barton, Jr.; Assistant Curators, Marian Lockwood, Robert R. Coles (on leave in Army Air Corps); Scientific Assistant, Fred Raiser; Lecturers, John Ball, Jr., Charles O. Roth, Jr.

